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ASPECTS OF NATURE,

IN

DIFFERENT LANDS AND DIFFERENT CLIMATES;

WITH

Scientific Elucidations.

BY

ALEXANDER VON HUMBOLDT.

TRANSLATED BY MRS. SABINE.

IN TWO VOLUMES.

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PHYSIOGNOMY OF PLANTS.

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ASPECTS OF NATURE

IN

DIFFERENT LANDS AND DIFFERENT CLIMATES.

PHYSIOGNOMY OF PLANTS.

When the active curiosity of man is engaged in interrogating Nature, or when his imagination dwells on the wide fields of organic creation, among the multifarious impressions which his mind receives, perhaps none is so strong and profound as that of the universal profusion with which life is everywhere distributed. Even on the polar ice the air resounds with the cries or songs of birds, and with the hum of insects. Nor is it only the lower dense and vaporous strata of the atmosphere which are thus filled with life, but also the higher and more ethereal regions. Whenever Mont Blanc or the summits of the Cordilleras have been ascended, living creatures have been found there. On the Chimborazo, (1) eight thousand feet higher than Etna, we found butterflies and other winged insects, borne by ascending currents of air to those almost unapproachable solitudes, which man, led by a restless curiosity or unappeasable thirst of knowledge, treads with adventurous but cautious steps: like him strangers in those elevated regions, their presence shows us that the more flexible organization of animal creation can subsist far beyond the limits at which vegetation ceases. The condor, (2) the giant of the Vulture tribe, often soared over our heads above all the summits of the Andes, at an altitude higher than would be the Peak of Teneriffe if piled on the snow-covered crests of the Pyrenees. The rapacity of this powerful bird attracts him to these regions, whence his far-seeing eye may discern the objects of his pursuit, the soft-wooled Vicunas, which, wandering in herds, frequent, like the Chamois, the mountain pastures adjacent to the regions of perpetual snow.

But if the unassisted eye sees life distributed throughout the atmosphere, when armed with the microscope we discover far other marvels. Rotiferæ, Brachionæ, and a multitude of microscopic animalculæ, are carried up by the winds from the surface of evaporating waters. These minute creatures, motionless and apparently dead, are borne to and fro in the air until the falling dews bring them back to the surface of the earth, dissolve the film or envelope which encloses their transparent rotating bodies, (3) and, probably by means of the oxygen which all waters contain, breathe new irritability into their dormant organs.

According to Ehrenberg's brilliant discovery, the yellow sand or dust which falls like rain on the Atlantic near the Cape de Verde Islands, and is occasionally carried even to Italy and Middle Europe, consists of a multitude of siliceous-shelled microscopic animals. Perhaps many of them float for years in the upper strata of the atmosphere, until they are brought down by vertical currents or in accompaniment with the superior current of the trade-winds, still susceptible of revivification, and multiplying their species by spontaneous division in conformity with the particular laws of their organisation.

But, besides creatures fully formed, the atmosphere contains innumerable germs of future life, such as the eggs of insects and the seeds of plants, the latter provided with light hairy or feathery appendages, by means of which they are wafted through the air during long autumnal wanderings. Even the fertilizing dust or pollen from the anthers of the male flowers, in species in which the sexes are separated, is carried over land and sea, by winds and by the agency of winged insects, (^{4}) to the solitary female plant on other shores. Thus wherever the glance of the inquirer into Nature penetrates, he sees the continual dissemination of life, either fully formed or in the germ.

If the aereal ocean in which we are submerged, and above the surface of which we cannot rise, be indispensable to the existence of organised beings, they also require a more substantial aliment, which they can find only at the bottom of this gaseous ocean. This bottom is of two kinds; the smaller portion consisting of dry land in immediate contact with the external atmosphere, and the larger portion consisting of water, which may perhaps have been formed thousands of years ago by electric agencies from gaseous substances, and which is now incessantly undergoing decomposition in the laboratories of Nature, in the clouds and in the pulsating vessels of animals and plants. Organic forms also descend deep below the surface of the earth, wherever rain or surface water can percolate either by natural cavities or by mines or other excavations made by man: the subterranean cryptogamic Flora was an object of my scientific research in the early part of my life. Thermal springs of very high temperature nourish small Hydropores, Confervæ, and Oscillatoria. At Bear Lake, near the Arctic Circle, Richardson saw the ground, which continues frozen throughout the summer at a depth of twenty inches, covered with flowering plants.

We do not yet know where life is most abundant,—whether on continents or in the unfathomed depths of the ocean. Through the excellent work of Ehrenberg, "Über das Verhalten des kleinsten Lebens," we have seen the sphere of organic life extend, and its horizon widen before our eyes, both in the tropical parts of the ocean and in the fixed or floating masses of ice of the Antarctic seas. Siliceous-shelled Polygastrica, and even Coscinodiscæ, with their green ovaries, have been found alive enveloped in masses of ice only twelve degrees from the Pole; the small black Glacier flea (Desoria glacialis) and Podurellæ inhabit the narrow tubular holes examined by Agassiz in the Swiss glaciers. Ehrenberg has shown that on several microscopic Infusoria (Synedra, Cocconeis) others live as parasites, and that in the Gallionellæ such is their prodigious power of development, or capability of division, that in the space of four days an animalcule invisible to the naked eye can form two cubic feet of the Bilin polishing slate. In the sea, gelatinous worms, living or dead, shine like stars, (5) and by their phosphoric light change the surface of the wide ocean into a sea of fire. Ineffaceable is the impression made on my mind by the calm nights of the torrid zone, on the waters of the Pacific. I still see the dark azure of the firmament, the constellation of the Ship near the zenith, and that of the Cross declining towards the horizon, shedding through the perfumed air their soft and planetary lustre; while bright furrows of flashing light marked the track of the dolphins through the midst of the foaming waves.

Not only the ocean, but also the waters of our marshes, hide from us an innumerable multitude of strange forms. The naked eye can with difficulty distinguish the Cyclidias, the Euglenes, and the host of Naids divisible by branches like the Lemna or Duckweed, of which they seek the shade. Other creatures inhabit receptacles where the light cannot penetrate, and an atmosphere variously composed, but differing from that which we breathe: such are the spotted Ascaris, which lives beneath the skin of the earthworm; the Leucophra, of a bright silvery colour, in the interior of the shore Naid; and a Pentastoma, which inhabits the large pulmonary cells of the rattlesnake of the tropics. (6) There are animalculæ in the blood of frogs and of salmon, and even, according to Nordmann, in the fluids of the eyes of fishes and in the gills of the Bleak. Thus the most hidden recesses of creation teem with life. We propose in these pages to direct our attention to the vegetable world, on the existence of which that of animals is dependent. Plants are incessantly engaged in disposing into order towards subsequent organization the raw materials of which the earth is composed: it is their office, by their vital forces or powers, to prepare those substances which, after undergoing a thousand modifications, are gradually converted to nobler purposes in the formation of nervous tissues. In directing our consideration towards the various families of plants, we shall at the same time glance at the multitude of animated beings to which they afford nutriment and protection.

The carpet of flowers and of verdure spread over the naked crust of our planet is unequally woven; it is thicker where the sun rises high in the ever cloudless heavens, and thinner towards the poles, in the less happy climes where returning frosts often destroy the opening buds of spring, or the ripening fruits of autumn. Everywhere, however, man finds some plants to minister to his support and enjoyment. If new lands are formed, the organic forces are ever ready to cover the naked rock with life. Sometimes, as at an early period among the Greek Islands, volcanic forces suddenly elevate above the surface of the boiling waves a rock covered with Scoriæ: sometimes, by a long-continued and more tranquil series of phenomena, the collective labours of united Lithophytes (7) raise their cellular dwellings on the crests of submarine mountains, until, after thousands of years, the structure reaches the level of the ocean, when the creatures which have formed it die, leaving a low flat coral island. How are the seeds of plants brought so immediately to these new shores? by wandering birds, or by the winds and waves of the ocean? The distance from other coasts makes it difficult to determine this question; but, no sooner is the rock of the newly raised islands in direct contact with the atmosphere, than there is formed on its surface, in our northern countries, a soft silky net-work, appearing to the naked eye as coloured spots and patches. Some of these patches are bordered by single or double raised lines running round their margins; other patches are crossed by similar lines traversing them in various directions. Gradually the light colour of the patches becomes darker, the bright yellow which was visible at a distance changes to brown, and the bluish gray of the Leprarias becomes a dusty black. The edges of neighbouring patches approach and run into each other; and on the dark ground thus formed there appear other lichens, of a circular shape and dazzling whiteness. Thus an organic film or covering establishes itself by successive layers; and as mankind, in forming settled communities, pass through different stages of civilisation, so is the gradual propagation and extension of plants connected with determinate physical laws. Lichens form the first covering of the naked rock, where afterwards lofty forest trees rear their airy summits. The successive growth of mosses, grasses, herbaceous plants, and shrubs or bushes, occupies the intervening period of long but undetermined duration. The part which lichens and mosses perform in the northern countries is effected within the tropics by Portulacas, Gomphrenas, and other low and succulent shore plants. The history of the vegetable covering of our planet, and its gradual propagation over the desert crust of the earth, has its epochs, as well as that of the migrations of the animal world.

Yet although organic life is everywhere diffused, and the organic powers are incessantly at work in reconnecting with each other the elements set free by death or dissolution, the abundance and variety of organised beings, and the rapidity with which they are renewed, differ in different climates. In the cold zones, the activity of organic life undergoes a temporary suspension during a portion of the year by frost; fluidity is an essential condition of life or vital action, and animals and plants, with the exception of mosses and other cryptogamia, are in those regions buried for several months of each year in winter sleep. Over a large part of the earth, therefore, there could only be developed organic forms capable of supporting either a considerable diminution of heat, or, being without leaves, a long interruption of the vital functions. Thus we see variety and grace of form, mixture of colours, and generally the perpetually youthful energy and vigour of organic life, increase as we approach the tropics. This increase can be denied only by those who have never quitted Europe, or who have neglected the study of physical geography. When, leaving our oak forests, we traverse the Alps or the Pyrenees, and enter Italy or Spain, or when we direct our attention to some of the African shores of the Mediterranean, we might easily be led to draw the erroneous inference that hot countries are marked by the absence of trees. But those who do so, forget that the South of Europe wore a different aspect on the first arrival of Pelasgian or Carthaginian colonies; they forget that an ancient civilisation causes the forests to recede more and more, and that the wants and restless activity of large communities of men gradually despoil the face of the earth of the refreshing shades which still rejoice the eye in Northern and Middle Europe, and which, even more than any historic documents, prove the recent date and youthful age of our civilization. The great catastrophe which occasioned the formation of the Mediterranean, when the swollen waters of what was previously an immense lake burst through the barriers of the Dardanelles and of the Pillars of Hercules, appears to have stripped the adjacent countries of a large portion of their coating of vegetable mould. The traditions of Samothrace, (8) handed down to us by Grecian writers, appear to indicate the recentness of the epoch of the ravages caused by this great change. In all the countries which surround the Mediterranean, and which are characterised by beds of the tertiary and cretaceous periods (nummulitic limestone and neocomian rocks), great part of the surface of the earth consists of naked rock. One especial cause of the picturesque beauty of Italian scenery is the contrast thus afforded between the bare rock, and the islands if I may so call them of luxuriant vegetation scattered over its surface. Wherever the rock is less intersected with fissures, so that it retains water at the surface, and where it is covered with vegetable mould, there, as on the enchanting shores of the Lake of Albano, Italy has her oak forests, with glades as deeply embowered and verdure as fresh as those which we admire in the North of Europe.

The deserts to the south of the Atlas, and the immense plains or steppes of South America, must be regarded as only local phenomena. The latter, the South American steppes, are clothed, in the rainy season at least, with grass, and with low-growing almost herbaceous mimosas. The African deserts are, indeed, at all seasons devoid of vegetation; seas of sand, surrounded by forest shores clothed with perpetual verdure. A few scattered fan-palms alone recall to the wanderer's recollection that these awful solitudes belong to the domain of the same animated terrestrial creation which is elsewhere so rich and so varied. The fantastic play of the mirage, occasioned by the effects of radiant heat, sometimes causes these palm trees to appear divided from the ground and hovering above its surface, and sometimes shews their inverted image reflected in strata of air undulating like the waves of the sea. On the west of the great Peruvian chain of the Andes, on the coasts of the Pacific, I have passed entire weeks in traversing similar deserts destitute of water.

The origin of extensive arid tracts destitute of plants, in the midst of countries rich in luxuriant vegetation, is a geognostical problem which has hitherto been but little considered, but which has doubtless depended on ancient revolutions of nature, such as inundations or great volcanic changes. When once a region has lost the covering of plants with which it was invested, if the sands are loose and mobile and are destitute of springs, and if the heated atmosphere, forming constantly ascending currents, prevents precipitation taking place from clouds (9), thousands of years may elapse ere organic life can pass from the verdant shores to the interior of the sandy sea, and repossess itself of the domain from which it had been banished.

Those, therefore, who can view nature with a comprehensive glance and apart from local phenomena, may see from the poles to the equator organic life and vigour gradually augment with the augmentation of vivifying heat, But, in the course of this progressive increase there are reserved to each zone its own peculiar beauties; to the tropics, variety and grandeur of vegetable forms; to the north, the aspect of its meadows and green pastures, and the periodic re-awakening of nature at the first breath of the mild air of spring. Each zone, besides its own peculiar advantages, has its own distinctive character. Primeval laws of organisation, notwithstanding a certain degree of freedom in the abnormal development of single parts, bind all animal and vegetable forms to fixed ever-recurring types. As we recognise in distinct organic beings a determinate physiognomy, and as descriptive botany and zoology, in the restricted sense of the terms, consist in a detailed analysis of animal and vegetable forms, so each region of the earth has a natural physiognomy peculiar to itself. The idea indicated by the painter by expressions such as "Swiss nature," "Italian sky," &c., rests on a partial perception of this local character in the aspect of nature. The azure of the sky, the lights and shadows, the haze resting on the distance, the forms of animals, the succulency of the plants and herbage, the brightness of the foliage, the outline of the mountains, are all elements which determine the total impression characteristic of each district or region. It is true that in every zone the same kinds of rocks, trachyte, basalt, porphyritic schists, and dolomite, form groups having the same physiognomy and aspect. The greenstone precipices of South America and Mexico resemble those of the Fichtel-Gebirge of Germany, just as among animals the form of the Alco, or native race of dogs of the New Continent, corresponds perfectly with that of the European race. For the inorganic crust of the globe shews itself independent of climatic influences; whether it be that differences of climate depending on differences of latitude were more recent than the formation of the rocks, or that the mass of the earth in solidifying and parting with its heat regulated its own temperature, (10) instead of receiving it from without. Thus all the kinds of rock with which we are acquainted may be met with in all parts of the globe, and everywhere affect the same characteristic forms. Everywhere basalt rises in twin mountains and truncated cones; everywhere the porphyritic trap appears in grotesquely arranged masses, and granite in rounded summits. Also similar forms of trees—pines and oaks—adorn the declivities of the mountains of Sweden, and those of the most southern part of Mexico. (11) Yet, notwithstanding these correspondences of form, and this similarity of outline in the component parts of the picture, their grouping gives to the whole the greatest difference of character.

Mineralogy is not more distinct from geology than is the individual description of natural objects from a general description of the physiognomy of nature. George Forster, in the narrative of his voyages, and in his other publications, —Goethe, in the descriptions of nature which so many of his immortal works contain,—Buffon, Bernardin de St. Pierre, and Chateaubriand, have traced with inimitable truth of description the character of some of the zones into which the earth is divided. Not only do such descriptions afford us mental enjoyment of a high order, but the knowledge of the character which nature assumes in different regions is moreover intimately connected with the history of man, and of his civilisation. For although the commencement of this civilisation is not solely determined by physical relations, yet the direction which it takes, the national character, and the more grave or gay dispositions of men, are dependent in a very high degree on climatic influences. How powerfully have the skies of Greece acted on its inhabitants! The nations settled in the fair and happy regions bounded by the Euphrates, the Halys, and the Egean Sea, also early attained amenity of manners and delicacy of sentiment. When in the middle ages religious enthusiasm suddenly re-opened the sacred East to the nations of Europe who were sinking back into barbarism, our ancestors in returning to their homes brought with them gentler manners, acquired in those delightful valleys. The poetry of the Greeks, and the ruder songs of the primitive northern nations, owe great part of their peculiar character to the aspect of the plants and animals seen by the bard, to the mountains and valleys which surrounded him, and to the air which he breathed. And to recall more familiar objects, who does not feel himself differently affected in the dark shade of the beech, on hills crowned with scattered fir-trees, or on the turfy pasture, where the wind rustles in the trembling foliage of the birch? These trees of our native land have often suggested or recalled to our minds images and thoughts, either of a melancholy, of a grave and elevating, or of a cheerful character. The influence of the physical on the moral world,—that reciprocal and mysterious action and reaction of the material and the immaterial,—gives to the study of nature, when regarded from higher points of view, a peculiar charm, still too little recognised.

But if the characteristic aspect of different portions of the earth's surface depends conjointly on all external phenomena,—if the contours of the mountains, the physiognomy of plants and animals, the azure of the sky, the form of the clouds, and the transparency of the atmosphere, all combine in forming that general impression which is the result of the whole, yet it cannot be denied that the vegetable covering with which the whole earth is adorned is the principal element in the impression. Animal forms are deficient in mass, and the individual power of motion which animals possess, as well as often the smallness of their size, withdraw them from our sight. The vegetable forms, on the contrary, produce a greater effect by their magnitude and by their constant presence. The age of trees is marked by their size, and the union of age with the manifestation of constantly renewed vigour is a charm peculiar to the vegetable kingdom. The gigantic Dragon-tree of Orotava, (12) (as sacred in the eyes of the inhabitants of the Canaries as the olive-tree in the Citadel of Athens, or the Elm of Ephesus), the diameter of which I found, when I visited those Islands, to be more than 16 feet, had the same colossal size, when the French adventurers, the Bétheneourts, conquered these gardens of the Hesperides in the beginning of the fifteenth century; yet it still flourishes, as if in perpetual youth, bearing flowers and fruit. A tropical forest of Hymenæas and Cæsalpinieæ may perhaps present to us a monument of more than a thousand years' standing.

If we embrace in one general view the different species of phænogamous plants at present contained in herbariums, the number of which may now be estimated at considerably above 80000, (13) we shall recognise in this prodigious multitude certain leading forms to which many others may be referred. In determining these leading forms or types, on the individual beauty, the distribution, and the grouping of which the physiognomy of the vegetation of a country depends, we must not follow the march of systems of botany, in which from other motives the parts chiefly regarded are the smaller organs of propagation, the flowers and the fruit; we must, on the contrary, consider solely that which by its mass stamps a peculiar character on the total impression produced, or on the aspect of the country. Among the leading forms of vegetation to which I allude, there are, indeed, some which coincide with families belonging to the "natural systems" of botanists. Such are the forms of Bananas, Palms, Casuarineæ, and Coniferæ. But the botanic systematist divides many groups which the physiognomist is obliged to unite. When plants or trees present themselves in masses, the outlines and distribution of the leaves and the form of the stems and of the branches are blended together. The painter (and here the artist's delicate tact and appreciation of nature are demanded) can distinguish in the middle distance and background of a landscape groves of palms or pines from beech woods, but he cannot distinguish the latter from woods consisting of other deciduous forest trees.

Above sixteen different forms of vegetation are principally concerned in determining the aspect or physiognomy of Nature. I mention only those which I have observed in the course of my travels both in the New and Old Continents, where during many years I have attentively examined the vegetation of the regions comprised between the 60th degree of North and the 12th degree of South latitude. The number of these forms will no doubt be considerably augmented when travellers shall have penetrated farther into the interior of Continents, and discovered new genera of plants. In the South-eastern part of Asia, the interior of Africa and of New Holland, and in South America from the river of the Amazons to the province of Chiquitos, the vegetation is still entirely unknown to us. How if at some future time a country should be discovered in which ligneous fungi, Cenomyce rangiferina, or mosses, should form tall trees? The Neckera dendroides, a German species of moss, is in fact arborescent; and bamboos (which are arborescent grasses) and the tree ferns of the tropics, which are often higher than our lime-trees and alders, now present to the European a sight as surprising as would be that of a forest of tree mosses to its discoverer. The absolute size and the degree of development attained by organic forms of the same family (whether plants or animals), depend on laws which are still unknown to us. In each of the great divisions of the animal kingdom, insects, crustacea, reptiles, birds, fishes, or mammalia, the size of the body oscillates between certain extreme limits. But these limits, which have been established by observation as far as it has yet gone, may be corrected by the discovery of species with which we are still unacquainted.

In land animals the higher temperatures of the low latitudes appear to have favoured organic development. The small and slender form of our lizards is exchanged in the south for the gigantic, heavy, and cuirassed bodies of crocodiles. In the formidable tiger, lion, and jaguar, we see repeated, on a larger scale, the form of the common cat, one of the smallest of our domestic animals. If we penetrate into the interior of the earth, and search the cemeteries in which the plants and animals of the ancient world lie entombed, the fossil remains which we discover not only announce a distribution inconsistent with our present climates,—they also disclose to us gigantic forms that contrast no less with those which now surround us, than does the simple heroism of the Greeks with the character of human greatness in modern times. Has the temperature of our planet undergone considerable changes,—possibly of periodical recurrence? If the proportion between land and sea, and even the height of the aerial ocean and its pressure, (14) have not always been the same, the physiognomy of nature, and the dimensions and forms of organised beings, must also have been subjected to various alterations. Huge Pachydermata, Mastodons, Owen's Mylodon robustus, and the Colossochelys, a land-tortoise above six feet high, have existed, and in the vegetable kingdom there have been forests composed of gigantic Lepidodendra, cactus-like Stigmarias, and numerous kinds of Cycadeæ. Unable to depict fully according to its present features the physiognomy of our planet in this its later age, I will only venture to attempt to indicate the characters which principally distinguish those vegetable groups which appear to me to be most strongly marked by physiognomic differences. However favoured by the richness and flexibility of our native language, it is still an arduous and hazardous undertaking when we attempt to trace in words that which belongs rather to the imitative art of the painter. I feel also the necessity of avoiding as much as possible the wearisome impression almost inseparable from all lengthened enumerations.

We will begin with palms, ([15]) the loftiest and noblest of all vegetable forms, that to which the prize of beauty has been assigned by the concurrent voice of nations in all ages; for the earliest civilisation of mankind belonged to countries bordering on the region of palms, and to parts of Asia where they abound. Their lofty, slender, ringed, and, in some cases, prickly stems, terminate in aspiring and shining either fanlike or pinnated foliage. The leaves are frequently curled, like those of some gramineæ. Smooth polished stems of palms carefully measured by me had attained 192 English feet in height. In receding from the equator and approaching the temperate zone, palms diminish in height and beauty. The indigenous vegetation of Europe only comprises a single representative of this form of plants, the sea-coast Dwarf-palm or Chamærops, which, in Spain and Italy, extends as far north as the 44th parallel of latitude. The true climate of palms has a mean annual temperature of 20°.5—22° Reaumur (78°.2—81°.5 Fahr). The Date, which is much inferior in beauty to several other genera, has been brought from Africa to the south of Europe, where it lives, but can scarcely be said to flourish, in a mean temperature not exceeding 12°—13°.5 Reaumur (59°—62°.4 Fahr). Stems of palms and fossil bones of elephants are found buried beneath the surface of the earth in northern countries, in positions which make it appear probable that their presence is not to be accounted for by their having been drifted thither from the tropics, and we are led to infer that in the course of the great revolutions which our planet has undergone, great changes of climate, and of the physiognomy of nature as dependent on climate, have taken place.

In all parts of the globe the palm form is accompanied by that of Plantains or Bananas; the Scitamineæ and Musaceæ of botanists, Heliconia, Amomum, and Strelitzia. In this form, the stems, which are low, succulent, and almost herbaceous, are surmounted by long, silky, delicately-veined leaves of a thin loose texture, and bright and beautiful verdure. Groves of plantains and bananas form the ornament of moist places in the equatorial regions. It is on their fruits that the subsistence of a large part of the inhabitants of the torrid zone chiefly depends, and, like the farinaceous cereals of the north, they have followed man from the infancy of his civilisation (16). The aboriginal site of this nutritious plant is placed by some Asiatic fables or traditions on the banks of the Euphrates, and by others, with more probability, at the foot of the Himalaya. Grecian fables named the fields of Enna as the happy native land of the cereals; and if in northern climes, where corn is cultivated in immense unbroken fields, their monotonous aspect adds but little to the beauty of the landscape, the inhabitant of the tropics, on the other hand, in rearing groves of plantains wherever he fixes his habitation, contributes to the adornment of the earth's surface by the extension of one of the most noble and beautiful forms of the vegetable world.

The form of Malvaceæ (17) and Bombaceæ, represented by Ceiba, Cavanillesia, and the Mexican hand-tree Cheirostemon, has enormously thick trunks; large, soft, woolly leaves, either heart-shaped or indented; and superb flowers frequently of a purple or crimson hue. It is to this group of plants that the Baobab, or monkey bread-tree, (Adansonia digitata), belongs, which, with a very moderate elevation, has a diameter of 32 English feet, and is probably the largest and most ancient organic monument on our planet. In Italy the Malvaceæ already begin to impart to the vegetation a peculiar southern character.

The delicately pinnated foliage of the Mimosa form (18), of which Acacia, Desmanthus, Gleditschia, Porleria, and

Tamarindus are important members, is entirely wanting in our temperate zone in the old continent, though found in the United States, where, in corresponding latitudes, vegetation is more varied and more vigorous than in Europe. The umbrella-like arrangement of the branches, resembling that seen in the stone pine of Italy, is very frequent among the Mimosas. The deep blue of the tropic sky seen through their finely divided foliage has an extremely picturesque effect.

The Heath form (19) belongs more especially to the old world, and particularly to the African continent and islands: taking for our guides physiognomic character and general aspect, we may class under it the Epacrideæ and Diosmeæ, many Proteaceæ, and those Australian Acacias which have mere leaf-stalks instead of leaves (phyllodias). This form has some points of similarity with that of needle trees, and the partial resemblance enhances the effect of the pleasing contrast which, when these two are placed together, is afforded by the abundant bell-shaped blossoms of the heaths. Arborescent heaths, like some other African plants, extend to the northern shores of the Mediterranean: they adorn Italy, and the cistus-covered grounds of the south of Spain. The declivity of the Peak of Teneriffe is the locality where I have seen them growing with the greatest luxuriance. In the countries adjoining the Baltic, and farther to the north, the aspect of this form of plants is unwelcome, as announcing sterility. Our heaths, Erica (Calluna) vulgaris, Erica tetralix, E. carnea, and E. cinerea, are social plants, and for centuries agricultural nations have combated their advance with little success. It is remarkable that the extensive genus which is the leading representative of this form appears to be almost limited to one side of our planet. Of the 300 known species of Erica only one has been discovered across the whole extent of the New Continent, from Pensylvania and Labrador to Nootka and Alashka.

The Cactus form, (20) on the other hand, is almost exclusively American. Sometimes spherical, sometimes articulated or jointed, and sometimes assuming the shape of tall upright polygonal columns resembling the pipes of an organ, this group presents the most striking contrast to those of Liliaceæ and Bananas. It comprises some of the plants to which Bernardin de St. Pierre has applied the term of "vegetable fountains in the desert." In the waterless plains of South America the animals suffering from thirst seek the melon-cactus, a spherical plant half buried in the dry sand, and encased in formidable prickles, but of which the interior abounds in refreshing juice. The stems of the columnar cactus rise to a height of 30 or 32 feet; they are often covered with lichens, and, dividing into candelabra-like branches, resemble, in physiognomy, some of the Euphorbias of Africa.

While the above-mentioned plants flourish in deserts almost devoid of other vegetation, the Orchideæ (21) enliven the clefts of the wildest rocks, and the trunks of tropical trees blackened by excess of heat. This form (to which the Vanilla belongs) is distinguished by its bright green succulent leaves, and by its flowers of many colours and strange and curious shape, sometimes resembling that of winged insects, and sometimes that of the birds which are attracted by the perfume of the honey vessels. Such is their number and variety that, to mention only a limited district, the entire life of a painter would be too short for the delineation of all the magnificent Orchideæ which adorn the recesses of the deep valleys of the Andes of Peru.

The Casuarina form (^{22}), leafless, like almost all species of Cactus, consists of trees with branches resembling the stalks of our Equisetums. It is found only in the islands of the Pacific and in India, but traces of the same singular rather than beautiful type are seen in other parts of the world. Plumier's Equisetum altissimum, Forskäl's Ephedra aphylla from the north of Africa, the Peruvian Colletias, and the Siberian Calligonum pallasia, are nearly allied to the Casuarina form.

As the Banana form shews the greatest expansion, so the greatest contraction of the leaf-vessels is shewn in Casuarinas, and in the form of Needle trees (^{23}) (Coniferæ). Pines, Thuias, and Cypresses, belong to this form, which prevails in northern regions, and is comparatively rare within the tropics: in Dammara and Salisburia the leaves, though they may still be termed needle-shaped, are broader. In the colder latitudes the never-failing verdure of this form of trees cheers the desolate winter landscape, and tells to the inhabitants of those regions that when snow and ice cover the ground the inward life of plants, like the Promethean fire, is never extinct upon our planet.

Like mosses and lichens in our latitudes, and like orchideæ in the tropical zone, plants of the Pothos form (^{24}) clothe parasitically the trunks of aged and decaying forest trees: succulent herbaceous stalks support large leaves, sometimes sagittate, sometimes either digitate or elongate, but always with thick veins. The flowers of the Aroideæ are cased in hooded spathes or sheaths, and in some of them when they expand a sensible increase of vital heat is perceived. Stemless, they put forth aerial roots. Pothos, Dracontium, Caladium, and Arum, all belong to this form, which prevails chiefly in the tropical world. On the Spanish and Italian shores of the Mediterranean, Arums combine with the succulent Tussilago, the Acanthus, and Thistles which are almost arborescent, to indicate the increasing luxuriance of southern vegetation.

Next to the last-mentioned form of which the Pothos and Arum are representatives, I place a form with which, in the hottest parts of South America, it is frequently associated, —that of the tropical twining rope-plants, or Lianes, (^{25}) which display in those regions, in Paullinias, Banisterias, Bignonias, and Passifloras, the utmost vigour of vegetation. It is represented to us in the temperate latitudes by our twining hops, and by our grape vines. On the banks of the Orinoco the leafless branches of the Bauhinias are often between 40 and 50 feet long: sometimes they hang down perpendicularly from the high top of the Swietenia, and sometimes they are stretched obliquely like the cordage of a ship: the tiger-cats climb up and descend by them with wonderful agility.

In strong contrast with the extreme flexibility and fresh light-coloured verdure of the climbing plants, of which we have just been speaking, are the rigid self-supporting growth and bluish hue of the form of Aloes, (26) which, instead of pliant stems and branches of enormous length, are either without stems altogether, or have branchless stems. The leaves, which are succulent, thick, and fleshy, and terminate in long points, radiate from a centre and form a closely crowded tuft. The tall-stemmed aloes are not found in close clusters or thickets like other social or gregarious plants or trees; they stand singly in arid plains, and impart thereby to the tropical regions in which they are found a peculiar, melancholy, and I would almost venture to call it, African character. Taking for our guides resemblance in physiognomy, and influence on the impression produced by the landscape, we place together under the head of the Aloe form, (from among the Bromeliaceæ) the Pitcairnias, which in the chain of the Andes grow out of clefts in the rocks; the great Pourretia pyramidata, (the Atschupalla of the elevated plains of New Granada); the American Aloe, (Agave); Bromelia ananas and B. karatas; from among the Euphorbiaceæ the rare species which have thick short candelabra-like divided stems; from the family of Asphodeleæ the African Aloe and the Dragon tree, (Dracæna draco); and lastly, from among the Liliaceæ, the tall flowering Yucca.

If the Aloe form is characterised by an almost mournful repose and immobility, the form of Gramineæ, (27) especially the physiognomy of arborescent grasses, is characterised, on the contrary, by an expression of cheerfulness and of airy grace and tremulous lightness, combined with lofty stature. Both in the East and West Indies groves of Bamboo form shaded over-arching walks or avenues. The smooth polished and often lightly-waving and bending stems of these tropical grasses are taller than our alders and oaks. The form of Gramineæ begins even in Italy, in the Arundo donax, to rise from the ground, and to determine by height as well as mass the natural character and aspect of the country.

The form of Ferns, (28) as well as that of Grasses, becomes ennobled in the hotter parts of the globe. Arborescent ferns, when they reach a height of above 40 feet, have something of a palm-like appearance; but their stems are less slender, shorter, and more rough and scaly than those of palms. Their foliage is more delicate, of a thinner and more translucent texture, and the minutely indented margins of the fronds are finely and sharply cut. Tree ferns belong almost entirely to the tropical zone, but in that zone they seek by preference the more tempered heat of a moderate elevation above the level of the sea, and mountains two or three thousand feet high may be regarded as their principal seat. In South America the arborescent ferns are usually found associated with the tree which has conferred such benefits on mankind by its fever-healing bark. Both indicate by their presence the happy region where reigns a soft perpetual spring.

I will next name the form of Liliaceous plants, (29) (Amaryllis, Ixia, Gladiolus, Pancratium) with their flag-like leaves and superb blossoms, of which Southern Africa is the principal country; also the Willow form (30), which is indigenous in all parts of the globe, and is represented in the elevated plains of Quito, (not in the shape of the leaves but in that of the ramification), by Schinus Molle; Myrtaceæ (³¹), (Metrosideros, Eucalyptus, Escallonia myrtilloides); Melastomaceæ (³²), and the Laurel form (³³).

It would be an enterprise worthy of a great artist to study the aspect and character of all these vegetable groups, not merely in hot-houses or in the descriptions of botanists, but in their native grandeur in the tropical zone. How interesting and instructive to the landscape painter (³⁴) would be a work which should present to the eye, first separately and then in combination and contrast, the leading forms which have been here enumerated! How picturesque is the aspect of tree-ferns spreading their delicate fronds above the laurel-oaks of Mexico; or groups of plantains overshadowed by arborescent grasses (Guaduas and Bamboos)! It is the artist's privilege, having studied these groups, to analyse them: and thus in his hands the grand and beautiful form of nature which he would pourtray resolves itself, (if I may venture on the expression) like the written works of men, into a few simple elements.

It is under the burning rays of a tropical sun that vegetation displays its most majestic forms. In the cold north the bark of trees is covered with lichens and mosses, whilst between the tropics the Cymbidium and fragrant Vanilla enliven the trunks of the Anacardias, and of the gigantic fig trees. The fresh verdure of the Pothos leaves, and of the Dracontias, contrasts with the many-coloured flowers of the Orchideæ. Climbing Bauhinias, Passifloras, and yellow flowering Banisterias, twine round the trunks of the forest trees. Delicate blossoms spring from the roots of the Theobroma, and from the thick and rough bark of the Crescentias and the Gustavia. (35) In the midst of this profusion of flowers and fruits, and in the luxuriant intertwinings of the climbing plants, the naturalist often finds it difficult to discover to which stem the different leaves and flowers really belong. A single tree adorned with Paullinias, Bignonias, and Dendrobium, forms a group of plants which, if disentangled and separated from each other, would cover a considerable space of ground.

In the tropics vegetation is generally of a fresher verdure, more luxuriant and succulent, and adorned with larger and more shining leaves than in our northern climates. The "social" plants, which often impart so uniform and monotonous a character to European countries, are almost entirely absent in the Equatorial regions. Trees almost as lofty as our oaks are adorned with flowers as large and as beautiful as our lilies. On the shady banks of the Rio Magdalena in South America, there grows a climbing Aristolochia bearing flowers four feet in circumference, which the Indian boys draw over their heads in sport, and wear as hats or helmets. (36) In the islands of the Indian Archipelago the flower of the Rafflesia is nearly three feet in diameter, and weighs above fourteen pounds.

The great elevation attained in several tropical countries not only by single mountains but even by extensive districts, enables the inhabitants of the torrid zone—surrounded by palms, bananas, and the other beautiful forms proper to those latitudes—to behold also those vegetable forms which, demanding a cooler temperature, would seem to belong to other zones. Elevation above the level of the sea gives this cooler temperature even in the hottest parts of the earth; and Cypresses, Pines, Oaks, Berberries and Alders, (nearly allied to our own) cover the mountainous districts and elevated plains of Southern Mexico and the chain of the Andes at the Equator. Thus it is given to man in those regions to behold without quitting his native land all the forms of vegetation dispersed over the globe, and all the shining worlds which stud the heavenly vault from pole to pole. (37)

These and many other of the enjoyments which Nature affords are wanting to the nations of the North. Many constellations, and many vegetable forms,—and of the latter, those which are most beautiful, (palms, tree ferns, plantains, arborescent grasses, and the finely-divided feathery foliage of the Mimosas),—remain for ever unknown to them. Individual plants languishing in our hot-houses can give but a very faint idea of the majestic vegetation of the tropical zone. But the high cultivation of our languages, the glowing fancy of the poet, and the imitative art of the painter, open to us sources whence flow abundant compensations, and from whence our imagination can derive the living image of that more vigorous nature which other climes display. In the frigid North, in the midst of the barren heath, the solitary student can appropriate mentally all that has been discovered in the most distant regions, and can create within himself a world free and imperishable as the spirit by which it is conceived.

ANNOTATIONS AND ADDITIONS.

(1) p. 3.—"*On the Chimborazo, eight thousand feet higher than Etna.*"

Small singing birds, and even butterflies, are found at sea at great distances from the coast, (as I have several times had opportunities of observing in the Pacific), being carried there by the force of the wind when storms come off the land. In the same involuntary manner insects are transported into the upper regions of the atmosphere, 16000 or 19000 feet above the plains. The heated crust of the earth occasions an ascending vertical current of air, by which light bodies are borne upwards. M. Boussingault, an excellent chemist who, as Professor at the newly instituted Mining Academy at Santa Fé de Bogota, visited the Gneiss Mountains of Caraccas, in ascending to the summit of the Silla witnessed, together with his companion Don Mariano de Rivero, a phenomenon affording a remarkable ocular demonstration of the fact of a vertically ascending current. They saw in the middle of the day, about noon, whitish shining bodies rise from the valley of Caraccas to the summit of the Silla, which is 5400 (5755 E.) feet high, and then sink down towards the neighbouring sea coast. These movements continued uninterruptedly for the space of an hour, and the objects, which at first were mistaken for a flock of small birds, proved to be small agglomerations of straws or blades of grass. Boussingault sent me some of the straws, which were immediately recognised by Professor Kunth for a species of Vilfa, a genus which, together with Agrostis, is very abundant in the provinces of Caraccas and Cumana: it was the Vilfa tenacissima of our Synopsis Plantarum æquinoctialium Orbis Novi, T. i. p. 205. Saussure found butterflies on Mont Blanc, as did Ramond in the solitudes which surround the summit of the Mont Perdu. When Bonpland, Carlos Montufar, and myself, reached, on the 23d of June, 1802, on the eastern declivity of the Chimborazo, the height of 18096 (19286 E.) feet—a height at which the barometer sank to 13 inches $11\frac{1}{5}$ lines (14.850 English inches), we saw winged insects fluttering around us. We could see that they were Dipteras, resembling flies, but on a sharp ridge of rock (cuchilla) often only ten inches wide, between steeply descending masses of snow, it was impossible to catch the insects. The height at which we saw them was nearly the same at which the uncovered trachytic rock, piercing through the eternal snows, gave to our view, in Lecidea geographica, the last traces of vegetation. The insects were flying at a height of about 2850 toises (18225 E. feet), or about 2600 E. feet higher than Mont Blanc. Somewhat lower down, at about 2600 toises (10626 E. feet), also therefore within the region of perpetual snow, Bonpland had seen yellow butterflies flying very near the ground. According to our present knowledge the Mammalia which live nearest to the region of perpetual snow are in the Swiss Alps, the Marmot which sleeps through the winter, and a very small field-mouse (Hypudæus nivalis), described by Martins, which on the Faulhorn lays up a store of the roots of phænogamous alpine plants almost under the snow. (Actes de la Société Helvétique, 1843, p. 324.) The beautiful Chinchilla, of which the bright and silky fur is so much prized, is often supposed by Europeans to be an inhabitant of the high mountain regions of Chili: this, however, is an error; the Chinchilla laniger (Gray) only lives in the mild temperature of the lower zone, and is not found farther south than the parallel of 35°. (Claudio Gay, Historia fisica y politica de Chile, Zoologia, 1844, p. 91.)

While on our European Alps, Lecideas, Parmelias, and Umbilicarias form only a few coloured patches on the rocks which are not completely covered with snow, in the Andes, beautiful flowering phænogamous plants, first described by us, live at elevations of thirteen to fourteen thousand feet (13700 to nearly 15000 E.) We found there woolly species of Culcitium and Espeletia (C. nivale, C. rufescens, and C. reflexum, E. grandiflora, and E. argentea), Sida pichinchensis, Ranunculus nubigenus, R. Gusmanni with red or orange-coloured blossoms, the small moss-like umbelliferous plant Myrrhis andicola, and Fragosa arctioides. On the declivity of the Chimborazo the Saxifraga boussingaulti, described by Adolph Brongniart, grows beyond the limit of perpetual snow on loose boulders of rock, at 14796 (15770 E.) feet above the level of the sea, not at 17000, as stated in two estimable English journals. (Compare my Asie Centrale, T. iii. p. 262, with Hooker, Journal of Botany, vol. i. 1834, p. 327, and Edinburgh New Philosophical Journal, vol. xvii. 1834, p. 380.) The Saxifrage discovered by Boussingault is certainly, up to the present time, the highest known phænogamous plant on the surface of the earth.

The perpendicular height of the Chimborazo is, according to my trigonometrical measurement, 3350 toises (21422 E. feet.) (Recueil d'Observ. Astron., vol. i., Introd. p. lxxii.) This result is intermediate between those given by French and Spanish academicians. The differences depend not on different assumptions for refraction, but on differences in the reduction of the measured base lines to the level of the sea. In the Andes this reduction could only be made by the barometer, and thus every measurement called a trigonometric measurement is also a barometric one, of which the result differs according to the first term in the formula employed. If in chains of mountains of great mass, such as the Andes, we insist on determining the greater part of the whole altitude trigonometrically, measuring from a low and distant point in the plain or nearly at the level of the sea, we can only obtain very small angles of altitude. On the other hand, not only is it difficult to find a convenient base among mountains, but also every step increases the portion of the height which must be determined barometrically. These difficulties have to be encountered by every traveller who selects, among the elevated plains which surround the Andes, the station at which he may execute his geodesical measurements. My measurement of the Chimborazo was made from the plain of Tapia, which is covered with pumice. It is situated to the west of the Rio Chambo, and its elevation, as determined by the barometer, is 1482 toises (9477 E. feet.) The Llanos de Luisa, and still more the plain of Sisgun, which is 1900 toises (12150 E. feet) high, would have given greater angles of altitude; I had prepared everything for making the measurement at the latter station when thick clouds concealed the summit of Chimborazo.

Those who are engaged in investigations on languages may not be unwilling to find here some conjectures respecting the etymology of the widely celebrated name of Chimborazo. Chimbo is the name of the Corregimiento or District in which the mountain of Chimborazo is situated. La Condamine (Voyage à l'Equateur, 1751, p. 184) deduces Chimbo from "chimpani," "to pass over a river." Chimbo-raço signifies, according to him, "la neige de l'autre bord," because at the village of Chimbo one crosses a stream in full view of the enormous snow-clad mountain. (In the Quichua language "chimpa" signifies the "other, or farther, side;" and chimpani signifies to pass or cross over a river, a bridge, &c.) Several natives of the province of Quito have assured me that Chimborazo signifies merely "the snow of Chimbo." We find the same termination in Carguai-razo. But razo appears to be a provincial word. The Jesuit Holguin, (whose excellent "Vocabulario de la Lengua general de todo el Peru llamada Lengua Qquichua ó del Inca," printed at Lima in 1608, is in my possession,) knows nothing of the word "razo." The genuine word for snow is "ritti." On the other hand, my learned friend Professor Buschmann remarks that in the Chinchaysuyo dialect (spoken north of Cuzco up to Quito and Pasto,) raju (the *j* apparently guttural) signifies snow; see the word in Juan de Figueredo's notice of Chinchaysuyo words appended to Diego de Torres Rubio, Arte, y Vocabulario de la Lengua Quichua, reimpr. en Lima, 1754; fol. 222, b. For the two first syllables of the name of the mountain, and for the village of Chimbo, (as chimpa and chimpani suit badly on account of the *a*), we may find a definite signification by means of the Quichua word chimpu, an expression used for a coloured thread or fringe (señal de lana, hilo ó borlilla de colores),—for the red of the sky (arreboles),—and for a halo round the sun or moon. One may try to derive the name of the mountain directly from this word, without the intervention of the village or district. In any case, and whatever the etymology of Chimborazo may be, it must be written in Peruvian Chimporazo, as we know that the Peruvians have no *b*.

But what if the name of this giant mountain should have nothing in common with the language of the Incas, but should have descended from a more remote antiquity? According to the generally received tradition, it was not long before the arrival of the Spaniards that the Inca or Quichua language was introduced into the kingdom of Quito, where the Puruay language, which has now entirely perished, had previously prevailed. Other names of mountains, Pichincha, Ilinissa, and Cotopaxi, have no signification at all in the language of the Incas, and are therefore certainly older than the introduction of the worship of the sun and the court language of the rulers of Cuzco. In all parts of the world the names of mountains and rivers are among the most ancient and most certain monuments or memorials of languages; and my brother Wilhelm von Humboldt has employed these names with great sagacity in his researches on the former diffusion of Iberian nations. A singular and unexpected statement has been put forward in recent years (Velasco Historia de Quito, T. i. p. 185) to the effect that "the Incas Tupac Yupanqui and Huayna Capac were astonished to find at their first conquest of Quito a dialect of the Quichua language already in use among the natives." Prescott, however, appears to regard this statement as doubtful. (Hist. of the Conquest of Peru, Vol. i. p. 115.)

If the Pass of St. Gothard, Mount Athos, or the Rigi, were placed on the summit of the Chimborazo, it would form an elevation equal to that now ascribed to the Dhawalagiri in the Himalaya. The geologist who rises to more general views connected with the interior of the earth, regards, not indeed the direction, but the relative height of the rocky ridges which we term mountain chains, as a phenomenon of so little import, that he would not be astonished if there should one day be discovered between the Himalaya and the Altai, summits which should surpass the Dhawaligiri and the Djawahir as much as these surpass the Chimborazo. (See my Vues des Cordillères et Monumens des peuples indigènes de l'Amérique, T. i. p. 116; and my Notice on two attempts to ascend the Chimborazo, in 1802 and 1831, in Schumacher's Jahrbuch for 1847, S. 176.) The great height to which the snow line on the northern side of the Himalaya is raised *in summer*, by the influence of the heat returned by radiation from the high plains of the interior of Asia, renders those mountains, although situated in 29 to 30½ degrees of latitude, as accessible as the Peruvian Andes within the tropics. Captain Gerard has attained on the Tarhigang an elevation as great, and perhaps (as is maintained in the Critical Researches on Philosophy and Geography) 117 English feet greater than that reached by me on the Chimborazo. Unfortunately, as I have shewn more at large in another place, these mountain journies beyond the limits of perpetual snow (however they may engage the curiosity of the public) are of only very inconsiderable scientific use.

(2) p. 4.—"*The Condor, the giant of the Vulture tribe.*"

In my Recueil d'Observations de Zoologie et d'Anatomie comparée, vol. i. pp. 26-45, I have given the natural history of the Condor, which, before my journey to the equatorial regions, had been much misrepresented. (The name of the bird is properly Cuntur in the Inca language; in Chili, in the Araucan, Mañque; Sarcoramphus Condor of Duméril.) I made and had engraved a drawing of the head from the living bird, and of the size of nature. Next to the Condor, the Lämmergeier of Switzerland, and the Falco destructor of Daudin, probably the Falco Harpyia of Linnæus, are the largest *flying* birds.

The region which may be regarded as the ordinary haunt of the Condor begins at the height of Etna, and comprises atmospheric strata from ten to eighteen thousand (about 10600 to 19000 English) feet above the level of the sea. Humming birds, which make summer excursions as far as 61° N. latitude on the north-west coast of America on the one hand, and the Tierra del Fuego on the other, have been seen by Von Tschudi (Fauna Peruana, Ornithol. p. 12) in Puna as high as 13700 (14600 English) feet. There is a pleasure in comparing the largest and the smallest of the feathered inhabitants of the air. Of the Condors, the largest individuals found in the chain of the Andes round Quito measured, with extended wings, 14 (nearly 15 English) feet, and the smallest 8 ($8\frac{1}{2}$ English) feet. From these dimensions, and from the visual angle at which the bird often appeared vertically above our heads, we are enabled to infer the enormous height to which the Condor soars when the sky is serene. A visual angle of 4′, for example, gives a perpendicular height above the eye of 6876 (7330 English) feet. The cave (Machay) of Antisana, which is opposite the mountain of Chussulongo, and from whence we measured the height of the soaring bird, is 14958 (15942 English) feet above the surface of the Pacific. This would give the absolute height attained by the Condor at fully 21834 (23270 English) feet; an elevation at which the barometer would hardly reach 12 French inches, but which yet does not surpass the highest summits of the Himalaya. It is a remarkable physiological phenomenon, that the same bird, which can fly round in circles for hours in regions of an atmosphere so rarified, should sometimes suddenly descend, as on the western declivity of the Volcano of Pichincha, to the sea-shore, thus passing rapidly through all gradations of climate. The membranous air-bags of the Condor, if filled in the lower regions of the atmosphere, must undergo extraordinary distension at altitudes of more than 23000 English feet. Ulloa, more than a century ago, expressed his astonishment that the vulture of the Andes could soar in regions where the atmospheric pressure is less than 14 French inches, (Voyage de l'Amérique meridionale, T. ii. p. 2, 1752; Observations astronomiques et physiques, p. 110). It was then believed, in analogy with experiments under the air-pump, that no animal could live in so low a pressure. I have myself, as I have already noticed, seen the barometer sink on the Chimborazo to 13 French inches 11·2 lines (14.850 English inches). Man, indeed, at such elevations, if wearied by muscular exertion, finds himself in a state of very painful exhaustion; but the Condor seems to perform the functions of respiration with equal facility under pressures of 30 and 13 English inches. It is apparently of all living creatures on our planet the one which can remove at pleasure to the greatest distance from the surface of the earth; I say at pleasure, for minute insects and siliceous-shelled infusoria are carried by the ascending current to possibly still greater elevations. The Condor probably flies higher than the altitude found as above by computation. I remember on the Cotopaxi, in the pumice plain of Suniguaicu, 13578 (14470 English) feet above the sea, to have seen the bird soaring at a height at which he appeared only as a small black speck. What is the smallest angle under which feebly illuminated objects can be discerned? Their form, (linear extension) has a great influence on the minimum of this angle. The transparency of the mountain atmosphere at the equator is such that, in the province of Quito, as I have elsewhere noticed, the white mantle or Poncho of a horseman was distinguished with the naked eye at a horizontal distance of 84132 (89665 English) feet; therefore under a visual angle of 13 seconds. It was my friend Bonpland, whom, from the pleasant country seat of the Marques de Selvalegre, we saw moving along the face of a black precipice on the Volcano of Pichincha. Lightning conductors, being long thin objects, are seen, as has already been remarked by Arago, from the greatest distances, and under the smallest angles.

The accounts of the habits of the Condor in the mountainous districts of Quito and Peru, given by me in a monograph on this powerful bird, have been confirmed by a later traveller, Gay, who has explored the whole of Chili, and has described that country in an excellent work entitled Historia fisica y politica de Chile. The Condor, which, like the Lamas, Vicunas, Alpacas, and Guanacos, does not extend beyond the equator into New Granada, is found as far south as the Straits of Magellan. In Chili, as in the mountain plains of Quito, the Condors, which at other times live either solitarily or in pairs, assemble in flocks to attack lambs and calves, or to carry off young Guanacos (Guanacillos). The ravages annually committed among the herds of sheep, goats, and cattle, as well as among the wild Vicunas, Alpacas, and Guanacos of the Andes, are very considerable. The inhabitants of Chili assert that, in captivity, the Condor can support forty days' hunger; when free, his voracity is excessive, and, vulture-like, is directed by preference to dead flesh.

The mode of capture of Condors in Peru by means of palisades, as described by me, is practised with equal success in Chili. When the bird has gorged himself with flesh, he cannot rise into the air without first running for some little distance with his wings half expanded. A dead ox, in which decomposition is beginning to take place, is strongly fenced round, leaving within the fence only a small space, in which the Condors attracted by the prey are crowded together. When they have gorged themselves with food, the palisades not permitting them to obtain a start by running, they become, as remarked above, unable to rise, and are either killed with clubs by the country people, or taken alive by the lasso. On the first declaration of the political independence of Chili, the Condor appeared on the coinage as the symbol of strength. (Claudio Gay, Historia fisica y politica de Chile, publicada bajo los auspicios del Supremo Gobierno; Zoologia, pp. 194-198.)

Far more useful than the Condor in the great economy of Nature, in the removal of putrefying animal substances and in thus purifying the air in the neighbourhood of human habitations, are the different species of Gallinazos, of which the number of individuals is much greater. In tropical America I have sometimes seen as many as 70 or 80 assembled at once round a dead animal; and I am able, as an eye-witness, to confirm the fact long since stated, but which has recently been doubted by ornithologists, of the whole assembly of these birds in such cases taking flight on the appearance of a single king-vulture, who yet is no larger than the Gallinazos. No combat ever takes place; but the Gallinazos (the two species of which, Cathartes urubu and C. aura, have been confounded with each other by an unfortunately fluctuating nomenclature) appear to be terrified by the sudden appearance and courageous demeanour of the richly coloured Sarcoramphus papa. As the ancient Egyptians protected the bird which rendered them similar services towards the purification of their atmosphere, so in Peru the careless or wanton killing of the Gallinazos is punished with a fine, which in some towns amounts, according to Gay, to 300 piastres for each bird. It is a remarkable circumstance, stated so long ago as by Don Felix de Azara, that these species of vultures, if taken young and reared, will so accustom themselves to the person who feeds them, that they will follow him on a journey for many miles, flying after the waggon in which he travels over the Pampas.

(3) p. 4.—"*Their rotating bodies.*"

Fontana, in his excellent work "Über das Viperngift," Bd. i. S. 62, relates that he succeeded, in the course of two hours, by means of a drop of water, in bringing to life a rotifera which had lain for two years and a half dried up and motionless. On the action and effect of water, see my "Versuche über die gereizte Muskel-und Nervenfaser," Bd. ii. S. 250.

What has been called the revivification of Rotiferæ, since observations have been more exact and have had to undergo stricter criticism, has been the subject of much animated discussion. Baker affirmed that he had resuscitated, in 1771, paste-eels which Needham had given him in 1744! Franz Bauer saw his Vibrio tritici, which had been dried up for four years, move again on being moistened. An extremely careful and experienced observer, Doyère, in his Mémoire sur les Tardigrades, et sur leur propriété de revenir à la vie (1842), draws from his own fine experiments the following conclusions:—Rotiferæ come to life, *i. e.* pass from a motionless state to a state of motion, after having been exposed to temperatures of 19°.2 Reaumur below, and 36° Reaumur above, the freezing point; *i. e.* from 11°.2 to 113°.0 Fah. They preserve the capability of apparent revivification, in *dry sand,* up to 56°.4 R. (158°.9 Fah.); but they lose it, and cannot be excited afresh, if heated in *moist sand* to 44° only (131°.0 Fah.) Doyère, p, 119. The possibility of revivification or reanimation is not prevented by their being placed for twenty-eight days in barometer tubes in vacuo, or even by the application of chloride of lime or sulphuric acid (pp. 130-133). Doyère has also seen the rotiferæ come to life again very slowly after being dried without sand (desséchés à nu), which Spallanzani had denied (pp. 117 and 129). "Toute dessiccation faite à la température ordinaire pourroit souffrir des objections auxquelles l'emploi du vide sec n'eût peut-être pas complètement repondu: mais en voyant les Tardigrades périr irrévocablement à une température de 44°, si leurs tissus sont pénétrés d'eau, tandis que desséchés ils supportent sans périr une chaleur qu'on peut évaluer à 96°

Reaumur, on doit être disposé à admettre que la revivification n'a dans l'animal d'autre condition que l'intégrité de composition et de connexions organiques." In the same way, in the vegetable kingdom, the sporules of cryptogamia, which Kunth compares to the propagation of certain phænogamous plants by buds (bulbillæ), retain their germinating power in the highest temperatures. According to the most recent experiments of Payen, the sporules of a minute fungus (Oïdium aurantiacum), which covers the crumb of bread with a reddish feathery coating, do not lose their power of germination by being exposed for half an hour in closed tubes to a temperature of from 67° to 78° Reaumur (182°.75 to 207°.5 Fah.), before being strewed on fresh perfectly unspoilt dough. May not the newly discovered monad (Monas prodigiosa), which causes blood-like spots on mealy substances, have been mingled with this fungus?

Ehrenberg, in his great work on Infusoria (S. 492-496), has given the most complete history of all the investigations which have taken place on what is called the revivification of rotiferæ. He believes that, in spite of all the means of desiccation employed, the organization-fluid still remains in the apparently dead animal. He contests the hypothesis of "latent life;" death, he says, is not "life latent, but the want of life."

We have evidence of the diminution, if not of the entire disappearance or suspension of organic functions, in the hybernation or winter sleep both of warm and cold-blooded animals, in the dormice, marmots, sand martins (Hirundo riparia) according to Cuvier (Règne animal, 1829, T. i. p.

396), frogs and toads. Frogs, awakened from winter-sleep by warmth, can support an eight times' longer stay under water without being drowned, than frogs in the breeding season. It would seem as if the functions of the lungs in respiration, for some time after their excitability had been suspended, required a less degree of activity. The circumstance of the sand-martin sometimes burying itself in a morass is a phenomenon which, while it seems not to admit of doubt, is the more surprising, as in birds respiration is so extremely energetic, that, according to Lavoisier's experiments, two small sparrows, in their ordinary state, decomposed, in the same space of time, as much atmospheric air as a porpoise. (Lavoisier, Mémoires de Chimie, T. i. p. 119.) The winter-sleep of the swallow in question (the Hirundo riparia) is not supposed to belong to the entire species, but only to have been observed in some individuals. (Milne Edwards, Elémens de Zoologie, 1834, p. 543.)

As in the cold zone the deprivation of heat causes some animals to fall into winter-sleep, so the hot tropical countries afford an analogous phænomenon, which has not been sufficiently attended to, and to which I have applied the name of summer-sleep. (Relation historique, T. ii. pp. 192 and 626.) Drought and continuous high temperatures act like the cold of winter in diminishing excitability. In Madagascar, (which, with the exception of a very small portion at its southern extremity, is entirely within the tropical zone,) as Bruguière had before observed, the hedgehog-like Tenrecs (Centenes, Illiger), one species of which (C. ecaudatus) has been introduced into the Isle of France, sleep during great heat. Desjardins makes, it is true, the objection that the time of their slumber is the winter season of the southern hemisphere; but in a country in which the mean temperature of the coldest month is 3° Reaumur (6°.75 Fah.) above that of the hottest month in Paris, this circumstance cannot change the three months' "summer-sleep" of the Tenrec in Madagascar and at Port Louis, into what we understand by a winter-sleep, or state of hybernation.

In the hot and dry season, the crocodile in the Llanos of Venezuela, the land and water tortoises of the Orinoco, the huge boa, and several smaller kinds of serpents, become torpid and motionless, and lie incrusted in the indurated soil. The missionary Gili relates that the natives, in seeking for the slumbering Terekai (land tortoises), which they find lying at a depth of sixteen or seventeen inches in dried mud, are sometimes bitten by serpents which become suddenly aroused, and which had buried themselves at the same time as the tortoise. An excellent observer, Dr. Peters, who has just returned from the East Coast of Africa, writes thus to me on the subject:—"During my short stay at Madagascar I could obtain no certain information respecting the Tenrec; but, on the other hand, I know that in the East of Africa, where I lived for several years, different kinds of tortoises (Pentonyx and Trionchydias) pass months during the dry season of this tropical country inclosed in the dry hard earth, and without food. The Lepidosiren also, in places where the swamps are dried up, remains coiled up and motionless, encased in indurated earth, from May to December."

Thus we find an annual enfeeblement of certain vital functions in many and very different classes of animals, and, what is particularly striking, without the same phenomena being presented by other living creatures nearly allied to them, and belonging to the same family. The northern glutton (Gulo), though allied to the badger (Meles), does not like him sleep during the winter; whereas, according to Cuvier's remark, "a Myoxus (dormouse) of Senegal (Myoxus coupeii), which could never have known winter-sleep in his tropical home, being brought to Europe fell asleep the first year on the setting in of winter." This torpidity or enfeeblement of the vital functions and vital activity passes through several gradations, according as it extends to the processes of nutrition, respiration, and muscular motion, or to depression of the activity of the brain and nervous system. The winter-sleep of the solitary bears and of the badger is not accompanied by any rigidity, and hence the reawakening of these animals is so easy, and, as was often related to me in Siberia, so dangerous to the hunters and country people. The first recognition of the gradation and connection of these phenomena leads us up to what has been called the "vita minima" of the microscopic organisms, which, occasionally with green ovaries and undergoing the process of spontaneous division, fall from the clouds in the Atlantic sand-rain. The apparent revivification of rotiferæ, as well as of the siliceous-shelled infusoria, is only the renewal of long-enfeebled vital functions,—

a state of vitality which was never entirely extinct, and which is fanned into a fresh flame, or excited anew, by the appropriate stimulus. Physiological phenomena can only be comprehended by being traced throughout the entire series of analogous modifications.

(4) p. 5.—" *Winged insects.*"

Formerly the fertilization of flowers in which the sexes are separated was ascribed principally to the action of the wind: it has been shown by Kölreuter, and with great ingenuity by Sprengel, that bees, wasps, and a host of smaller winged insects, are the chief agents. I say the chief agents, because to assert that no fertilization is possible without the intervention of these little animals appears to me not to be in conformity with nature, as indeed has been shown in detail by Willdenow. (Grundriss der Kräuterkunde, 4te Aufl., Berl. 1805, S. 405-412.) On the other hand, Dichogamy, coloured spots or marks indicating honey-vessels (maculæ indicantes), and fertilization by insects, are, in much the greater number of cases, inseparably associated. (Compare Auguste de St. Hilaire, Leçons de Botanique, 1840, p. 565-571.)

The statement which has been often repeated since Spallanzani, that the diœcious common hemp (Cannabis sativa) yields perfect seeds without the neighbourhood of pollen-bearing vessels, has been refuted by later experiments. When seeds have been obtained, anthers in a rudimentary state, capable of furnishing some grains of fertilizing dust, have been discovered near the ovarium. Such hermaphroditism is frequent in the entire family of Urticeæ, but a peculiar and still unexplained phenomenon has been presented in the forcing-houses at Kew by a small New Holland shrub, the Cœlebogyne of Smith. This phænogamous plant produces in England perfect seeds without trace of male organs, or the hybridising introduction of the pollen of other species. An ingenious botanist, Adrien de Jussieu, in his "Cours Elementaire de Botanique," 1840, p. 463, expresses himself on the subject as follows:—Un genre d'Euphorbiacées (?) assez nouvellement décrit mais cultivé depuis plusieurs années dans les serres d'Angleterre, le Cœlebogyne, y a plusieurs fois fructifié, et ses graines étaient évidemment parfaites, puisque non seulement on y a observé un embryon bien constitué, mais qu'en le semant cet embryon s'est développé en une plante semblable. Or les fleurs sont dioïques; on ne connait et ne possède pas (en Angleterre) de pieds mâles, et les recherches les plus minutieuses, faites par les meilleurs observateurs, n'ont pu jusqu'ici faire découvrir la moindre trace d'anthères ou seulement de pollen. L'embryon ne venait donc pas de ce pollen, qui manque entièrement: il a dû se former de toute pièce dans l'ovule."

In order to obtain a fresh confirmation or elucidation of this highly important and isolated phenomenon, I addressed myself not long since to my young friend Dr. Joseph Hooker, who, after making the Antarctic voyage with Sir James Ross, has now joined the great Thibeto-Himalayan expedition. Dr. Hooker wrote to me in reply, on his arrival at Alexandria near the end of December 1847, before embarking at Suez: "Our Cœlebogyne still flowers with my father at Kew as well as in the Gardens of the Horticultural Society. It ripens its seeds regularly: I have examined it repeatedly very closely and carefully, and have never been able to discover a penetration of pollen-tubes either in the style or ovarium. In my herbarium the male blossoms are in small catkins."

(5) p. 7.—"*Shine like stars.*"

The luminosity of the ocean is one of those superb natural phenomena which continue to excite our admiration even when we have seen them recur every night for months. The sea is phosphorescent in every zone; but those who have not witnessed the phenomenon within the tropics, and especially in the Pacific, have only an imperfect idea of the grand and majestic spectacle which it affords. When a man-of-war, impelled by a fresh breeze, cuts the foaming waves, the voyager standing at the ship's side feels as if he could never be satisfied with gazing on the spectacle which presents itself to his view. Every time that in the rolling of the vessel her side emerges from the water, blue or reddish streams of light appear to dart upwards like flashes of lightning from her keel. Nor can I describe the splendour of the appearance presented on a dark night in the tropic seas by the sports of a troop of porpoises. As they cut through the foaming waves, following each other in long winding lines, one sees their mazy track marked by intense and sparkling light. In the Gulf of Cariaco, between Cumana and the Peninsula of Maniquarez, I have stood for hours enjoying this spectacle.

Le Gentil and the elder Forster attributed the flashing to the electric friction excited by the ship in moving through the water, but the present state of our knowledge does not permit us to receive this as a valid explanation. (Joh. Reinh. Forster's Bemerkungen auf seiner Reise um die Welt, 1783, S. 57; Le Gentil, Voyage dans les Mers de l'Inde, 1779, T. i. p. 685-698.)

Perhaps there are few natural subjects of observation which have been so long and so much debated as the luminosity of the waters of the sea. What we know with certainty on the subject may be reduced to the following simple facts. There are several luminous animals which, when alive, give out at pleasure a faint phosphoric light: this light is, in most instances, rather bluish, as in Nereis noctiluca, Medusa pelagica var. β (Forskäl, Fauna Ægyptiaco-arabica, s. Descriptiones animalium quæ in itinere orientali observavit, 1775, p. 109), and in the Monophora noctiluca, discovered in Baudin's expedition, (Bory de St.-Vincent, Voyage dans les Iles des Mers d'Afrique, 1804, T. i. p. 107, pl. vi.) The luminous appearance of the sea is due partly to living animals, such as are spoken of above, and partly to organic fibres and membranes derived from the destruction of these living torch-bearers. The first of these causes is undoubtedly the most usual and most extensive. In proportion as travellers engaged in the investigation of natural phenomena have become more zealous in their researches, and more experienced in the use of excellent microscopes, we have seen in our zoological systems the groups of Mollusca and Infusoria, which become luminous either at pleasure or when excited by external stimulus, increase more and more.

The luminosity of the sea, so far as it is produced by living organic beings, is principally due, in the class of Zoophytes, to the Acalephæ (the families of Medusa and Cyanea), to some Mollusca, and to a countless host of Infusoria. Among the small Acalephæ, the Mammaria scintillans offers the beautiful spectacle of, as it were, the starry firmament reflected by the surface of the sea. This little creature, when full grown, hardly equals in size the head of a pin. Michaelis, at Kiel, was the first to show that there are luminous siliceous-shelled infusoria: he observed the flashing light of the Peridinium (a ciliated animalcule), of the cuirassed Monad the Prorocentrum micans, and of a rotifera to which he gave the name of Synchata baltica. (Michaelis über das Leuchten der Ostsee bei Kiel, 1830, S. 17.) The same Synchata baltica was subsequently discovered by Focke in the Lagunes of Venice. My distinguished friend and Siberian travelling companion, Ehrenberg, has succeeded in keeping luminous infusoria from the Baltic alive for almost two months in Berlin. He shewed them to me in 1832 with a microscope in a drop of sea-water: placed in the dark I saw their flashes of light. The largest of these little infusoria were 1-8th, and the smallest from 1-48th to 1-96th of a Paris line in length (a Paris line is about nine-hundredths of an English inch): after they were exhausted, and had ceased to send forth sparkles of light, the flashing was renewed on their being stimulated by the addition of acids or of a little alcohol to the sea-water.

By repeatedly filtering water taken up fresh from the sea, Ehrenberg succeeded in obtaining a fluid in which a greater number of these luminous creatures were concentrated.

magnetic lightnings), which, as the result of an increased tension in the interior of the globe, are announced for hours beforehand by the suddenly altered movements of the magnetic needle. (See my letter to the Editor of the Annalen der Physik und Chemie, Bd. xxxvii. 1836, S. 242-244).

Sometimes one cannot even with high magnifying powers discern any animalcules in the luminous water; and yet, whenever the wave strikes and breaks in foam against a hard body, a light is seen to flash. In such case the cause of the phenomenon probably consists in the decaying animal fibres, which are disseminated in immense abundance throughout the body of water. If this luminous water is filtered through fine and closely woven cloths, these little fibres and membranes are separated in the shape of shining points. When we bathed at Cumana in the waters of the Gulf of Cariaco, and afterwards lingered awhile on the solitary beach in the mild evening air without our clothes, parts of our bodies continued luminous from the shining organic particles which had adhered to the skin, and the light only became extinct at the end of some minutes. Considering the enormous quantity of animal life in all tropical seas, it is, perhaps, not surprising that the sea water should be luminous, even where no visible organic particles can be detached from it. From the almost infinite subdivision of the masses of dead Dagysæ and Medusæ, the sea may perhaps be looked on as a gelatinous fluid, which as such is luminous, distasteful to, and undrinkable by man, and capable of affording nourishment to many fish. If one rubs a board with part of a Medusa hysoeella, the part so rubbed regains its luminosity on friction with a dry finger. On my passage to South America I sometimes placed a Medusa on a tin plate. When I struck another metallic substance against the plate, the slightest vibrations of the tin were sufficient to cause the light. What is the manner in which in this case the blow and the vibrations act? Is the temperature momentarily augmented? Are new surfaces exposed? or does the blow press out a fluid, such as phosphuretted hydrogen, which may burn on coming into contact with the oxygen of the atmosphere or of the air held in solution by the sea-water. This light-exciting influence of a shock or blow is particularly remarkable in a "cross sea," *i. e.* when waves coming from opposite directions meet and clash.

I have seen the sea within the tropics appear luminous in the most different states of weather; but the light was most brilliant when a storm was near, or with a sultry atmosphere and a vaporous thickly-clouded sky. Heat and cold appear to have little influence on the phenomenon, for on the Banks of Newfoundland the phosphorescence is often very bright during the coldest winter weather. Sometimes under apparently similar external circumstances the sea will be highly luminous one night and not at all so the following night. Does the atmosphere influence the disengagement of light, or do all these differences depend on the accident of the observer sailing through a part of the sea more or less abundantly impregnated with gelatinous animal substances? Perhaps it is only in certain states of the magnetic lightnings), which, as the result of an increased tension in the interior of the globe, are announced for hours beforehand by the suddenly altered movements of the magnetic needle. (See my letter to the Editor of the Annalen der Physik und Chemie, Bd. xxxvii. 1836, S. 242-244).

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Respecting the wonderful development of mass and power of increase in Infusoria, see Ehrenberg, Infus. S. xiii. 291 and 512. He observes that "the galaxy of the minutest organisms passes through the genera of Vibrio and Bacterium and that of Monas, (in the latter they are often only $\frac{1}{3000}$ of a line,) S. xix. and 244.

(6) p. 7.—"*Which inhabits the large pulmonary cells of the rattle-snake of the tropics.*"

This animal, which I formerly called an Echinorhynchus or even a Porocephalus, appears on closer investigation, and according to the better founded judgment of Rudolphi, to belong to the division of the Pentastomes. (Rudolphi, Entozoorum Synopsis, p. 124 and 434.) It inhabits the ventral cavities and wide-celled lungs of a species of Crotalus which lives in Cumana, sometimes in the interior of houses, where it pursues the mice. Ascaris lumbrici (Gözen's Eingeweidewürmer, Tab. iv. Fig. 10,) lives under the skin of the common earthworm, and is the smallest of all the species of Ascaris. Leucophra nodulata, Gleichen's pearl-animalcule, has been observed by Otto Friedrich Müller in the interior of the reddish Nais littoralis. (Müller, Zoologia danica, Fasc. II. Tab. lxxx. a—e.) Probably these microscopic animals are again inhabited by others. All are surrounded by air poor in oxygen and variously mixed with hydrogen and carbonic acid. Whether any animal can live in *pure nitrogen* is very doubtful. It might formerly have been believed to be the case with Fischer's Cistidicola farionis, because according to Fourcroy's experiments the swimming bladders of fish appeared to contain an air entirely deprived of oxygen. Erman's experience and my own shew, however, that fresh-water fishes never contain pure nitrogen in their swimming bladders. (Humboldt et Provençal, sur la respiration des Poissons, in the Recueil d'Observ. de Zoologie, Vol. ii. p. 194-216.) In sea-fish as much as 0·80 of oxygen has been found, and according to Biot the purity of the air would appear to depend on the depth at which the fish live. (Mémoires de Physique et de Chimie de la Societé d'Arcueil, T. i. 1807, p. 252-281.)

(7) p. 8.—*"The collected labours of united Lithophytes."*

Following Linnæus and Ellis, the calcareous zoophytes,—among which Madrepores, Meandrinæ, Astreæ, and Poeilloporæ, especially, produce wall-like coral-reefs,—are inhabited by living creatures which were long believed to be allied to the Nereids belonging to Cuvier's Annelidæ. The anatomy of these gelatinous little creatures has been elucidated by the ingenious and extensive researches of Cavolini, Savigny, and Ehrenberg. We have learnt that in order to understand the entire organization of what are called the rock-building coral animals, the scaffolding which survives them, *i. e.*, the layers of lime, which in the form of thin delicate plates or lamellæ are elaborated by vital functions, must not be regarded as something extraneous to the soft membranes of the food-receiving animal.

Besides the more extended knowledge of the wonderful formation of the animated coral stocks, there have been gradually established more accurate views respecting the influence exercised by corals on other departments of Nature,—on the elevation of groups of low islands above the level of the sea,—on the migrations of land-plants and the successive extension of the domains of particular Floras,—and, lastly, in some parts of the ocean, on the diffusion of races of men, and the spread of particular languages.

As minute organic creatures living in society, corals do indeed perform an important part in the general economy of Nature, although they do not, as was begun to be believed at the time of Cook's voyages, enlarge continents and build up islands from fathomless depths of the ocean. They excite the liveliest interest, whether considered as subjects of physiology and of the study of the gradation of animal forms, or whether they are regarded in reference to their influence on the geography of plants and on the geological relations of the crust of the Earth. According to the great views of Leopold von Buch, the whole formation of the Jura consists of "large raised coral-banks of the ancient world surrounding the ancient mountain chains at a certain distance."

In Ehrenberg's Classification, (Abhandlungen der Akad. der Wiss. zu Berlin aus dem, J. 1832, S. 393-432) Coral-animals, (often improperly called, in English works, Coral-insects) are divided into two great classes: the single-mouthed Anthozoa, which are either free or capable of detaching themselves, being the animal-corals, Zoocorallia; and those in which the attachment is permanent and plant-like, being the Phyto-corals. To the first order, the Zoocorallia, belong the Hydras or Arm-polypi of Trembley, the Actiniæ decked with beautiful colours, and the mushroom-corals; to the second order or Phyto-corals belong the Madrepores, the Astræids, and the Ocellinæ. The Polypi of the second order are those which, by the cellular wave-defying ramparts which they construct, are the principal subject of the present note. These ramparts consist of an aggregate of coral trunks, which, however, do not instantly lose their common vitality as does a forest tree when cut down.

Every coral-trunk is a whole which has arisen by a formation of buds taking place according to certain laws, the parts of which the whole consists forming a number of organically distinct individuals. In the group of Phyto-corals these individuals cannot detach themselves at pleasure, but remain united with each other by thin plates of carbonate of lime. It is not, therefore, by any means the case that each trunk of coral has a central point of common vitality or life. (See Ehrenberg's Memoir above referred to, S. 419.) The propagation of coral-animals takes place, in the one order, by eggs or by spontaneous division; and in the other order, by the formation of buds. It is the latter mode of propagation which, in the development of individuals, is the most rich in variety of form.

Coral-reefs, (according to the definition of Dioscorides, sea-plants, a forest of stone-trees, Lithodendra), are of three kinds;—coast reefs, called by the English "shore or fringing reefs," which are immediately connected with the coasts of continents or islands, as almost all the coral banks of the Red Sea seen during an eighteen months' examination by Ehrenberg and Hemprich;—"barrier-reefs," "encircling-reefs," as the great Australian barrier-reef on the north-east coast of New Holland, extending from Sandy Cape to the dreaded Torres Strait; and as the encircling-reefs surrounding the islands of Vanikoro (between the Santa Cruz group and the New Hebrides) and Poupynete (one of the Carolinas;—and lastly, coral banks enclosing lagoons, forming "Atolls" or "Lagoon-islands." This highly natural division and nomenclature have been introduced by Charles Darwin, and are intimately connected with the explanation which that ingenious and excellent investigator of nature has given of the gradual production of these wonderful forms. As on the one hand Cavolini, Ehrenberg, and Savigny have perfected the scientific-anatomical knowledge of the organisation of coral-animals, so on the other hand the geographical and geological relations of coral-islands have been investigated and elucidated, first by Reinhold and George Forster in Cook's Second Voyage, and subsequently, after a long interval, by Chamisso, Péron, Quoy and Gaimard, Flinders, Lütke, Beechey, Darwin, d'Urville, and Lottin.

The coral-animals and their stony cellular structures or scaffolding belong principally to the warm tropical seas, and the reefs are found more frequently in the Southern than in the Northern Hemisphere. The Atolls or Lagoon Islands are crowded together in what has been called the Coral-Sea, off the north-east coast of New Holland, including New Caledonia, the Salomon's Islands, and the Louisiade Archipelago; in the group of the Low islands (Low Archipelago), eighty in number; in the Fidji, Ellice, and Gilbert groups; and in the Indian Ocean, on the north-east of Madagascar, under the name of the Atoll-group of Saya de Malha.

The great Chagos bank, of which the structure and rocks of dead coral have been thoroughly examined by Captain Moresby and by Powell, is so much the more interesting, because we may regard it as a continuation of the more northerly Laccadives and Maldives. I have already called attention elsewhere (Asie Centrale, T. i. p. 218), to the importance of the succession of these Atolls, running exactly in the direction of a meridian and continued as far as 7°

south latitude, to the general system of mountains and the configuration of the earth's surface in Central Asia. They form a kind of continuation to the great rampart-like mountain elevations of the Ghauts and the more northern chain of Bolor, to which correspond in the trans-Gangetic Peninsula the North and South Chains which are intersected near the great bend of the Thibetian Tzang-bo River by several transverse mountain systems running east and west. In this eastern peninsula are situated the chains of Cochin China, Siam, and Malacca which are parallel with each other, as well as those of Ava and Arracan which all, after courses of unequal length, terminate in the Gulfs or Bays of Siam, Martaban, and Bengal. The Bay of Bengal appears like an arrested attempt of nature to form an inland sea. A deep invasion of the ocean, between the simple western system of the Ghauts, and the eastern very complex trans-Gangetic system of mountains, has swallowed up a large portion of the low lands on the eastern side, but met with an obstacle more difficult to overcome in the existence of the extensive high plateau of Mysore.

Such an invasion of the ocean has occasioned two almost pyramidal peninsulas of very different dimensions, and differently proportioned in breadth and length; and the continuations of two mountain systems (both running in the direction of the meridian, *i. e.*, the mountain system of Malacca on the east, and the Ghauts of Malabar on the west), shew themselves in submarine chains of mountains or symmetrical series of islands, on the one side in the Andaman and Nicobar Islands which are very poor in corals, and on the other side in the three long-extended groups or series of Atolls of the Laccadives, the Maldives, and Chagos. The latter series, called by navigators the Chagos-bank, forms a lagoon encircled by a narrow and already much broken, and in great measure submerged, coral reef. The longer and shorter diameters of this lagoon, or its length and breadth, are respectively 90 and 70 geographical miles. Whilst the enclosed lagoon is only from seventeen to forty fathoms deep, the depth of water at a small distance from the outer margin of the coral, (which appears to be gradually sinking), is such, that at half a mile no bottom was found in sounding with a line of 190 fathoms, and, at a somewhat greater distance, none with 210 fathoms. (Darwin, Structure of Coral Reefs, p. 39, 111, and 183.) At the coral lagoon called Keeling-Atoll, Captain Fitz-Roy, at a distance of only two thousand yards from the reef, found no soundings with 1200 fathoms.

"The corals which, in the Red Sea, form thick wall-like masses, are species of Meandrina, Astræa, Favia, Madrepora (Porites), Poeillopora (hempriehii), Millepora, and Heteropora. The latter are among the most massive, although they are somewhat branched. The corals which lie deepest below the surface of the water in this locality, and which, being magnified by the refraction of the rays of light, appear to the eye like the domes or cupolas of a cathedral or other large building, belong, so far as we were enabled to judge, to Meandrina and Astræa." (Ehrenberg, manuscript notices.) It is necessary to distinguish between separate and in part free and detached polypifers, and those which form wall-like structures and rocks.

If we are struck with the great accumulation of building polypifers in some regions of the globe, it is not less surprising to remark the entire absence of their structures in other and often nearly adjoining regions. These differences must be determined by causes which have not yet been thoroughly investigated; such as currents, local temperature of the water, and abundance or deficiency of appropriate food. That certain thin-branched corals, with less deposit of lime on the side opposite to the opening of the mouth, prefer the repose of the interior of the lagoon, is not to be denied; but this preference for the unagitated water must not, as has too often been done (Annales des Sciences Naturelles, 1825, T. vi. p. 277), be regarded as a property belonging to the entire class. According to Ehrenberg's experience in the Red Sea, that of Chamisso in the Atolls of the Marshall Islands east of the Caroline group, the observations of Captain Bird Allen in the West Indies, and those of Capt. Moresby in the Maldives, living Madrepores, Millepores, and species of Astræa and of Meandrina, can support the most violent action of the waves,—"a tremendous surf,"—(Darwin, Coral Reefs, pp. 63-65), and even appear to prefer the most stormy exposure. The living organic forces or powers regulating the cellular structure, which with age acquires the hardness of rock, resist with wonderful success the mechanical forces acting in the shock of the agitated water.

In the Pacific, the Galapagos Islands, and the whole

Western Coast of America, are entirely without coral reefs, although so near to the many Atolls of the Low Islands, and the Archipelago of the Marquesas. This absence of corals might perhaps be ascribed to the presence of colder water, since we know that the coasts of Chili and Peru are washed by a cold current coming from the south and turning to the westward off Punta Parina, the temperature of which I found, in 1802, to be only 12°.5 Reaumur (60°.2 Fah.), while the undisturbed adjacent masses of water were from 22° to 23° Reaumur (81°.5 to 83°.8 Fah.); and there are also among the Galapagos small currents running between the islands, having a temperature of only 11°.7 Reaumur (58°.2 Fah.) But these lower temperatures do not extend farther to the north along the shores of the Pacific, and are not found upon the coasts of Guayaquil, Guatimala, and Mexico; nor does a low temperature prevail at the Cape de Verd Islands on the West Coast of Africa, or at the small islands of St. Paul (St. Paul's rocks), or at St. Helena, Ascension, or San Fernando Noronha,—which yet are all without coral reefs.

While this absence of coral reefs appears to characterise the *western* coasts of Africa, America, and Australia, on the other hand such reefs abound on the *eastern* coasts of tropical America, of Africa, on the coasts of Zanzibar and Australia, and on that of New South Wales. The coral banks which I have chiefly had opportunities of observing are those of the interior of the Gulf of Mexico, and those to the south of the Island of Cuba, in what are called the "Gardens of the King and Queen" (Jardines y Jardinillos del Rey y de la Reyna). It was Columbus himself who, on his second voyage, in May 1494, gave that name to this little group of islands, because the agreeable mixture of the silver-leaved arborescent Tournefortia gnapholoides, flowering species of Dolichos, Avicennia nitida, and mangrove hedges, gave to the coral islands the appearance of a group of floating gardens. "Son Cayos verdes y graciosos llenos de arboledas," says the Admiral. On the passage from Batabano to Trinidad de Cuba, I remained several days in these gardens, situated to the east of the larger island, called the Isla de Pinos, which is rich in mahogany trees: my stay was for the purpose of determining the longitude of the different keys (Cayos). The Cayo Flamenco, Cayo Bonito, Cayo de Diego Perez, and Cayo de piedras, are coral islands rising only from eight to fourteen inches above the level of the sea. The upper edge of the reef does not consist simply of blocks of dead coral; it is rather a true conglomerate, in which angular pieces of coral, cemented together with grains of quartz, are embedded. In the Cayo de piedras I saw such embedded pieces of coral measuring as much as three cubic feet. Several of the small West Indian coral islands have fresh water, a phenomenon which, wherever it presents itself, (for example, at Radak in the Pacific; see Chamisso in Kotzebue's Entdeckungs-Reise, Bd. iii. S. 108), is deserving of examination, as it has sometimes been ascribed to hydrostatic pressure operating from a distant coast, (as at Venice, and in the Bay of Xagua east of Batabano), and sometimes to the filtration of rain water. (See my Essai politique sur l'Ile de Cuba, T. ii. p. 137.)

The living gelatinous investment of the stony calcareous part of the coral attracts fish, and even turtles, who seek it as food. In the time of Columbus the now unfrequented locality of the Jardines del Rey was enlivened by a singular kind of fishery, in which the inhabitants of the coasts of the Island of Cuba engaged, and in which they availed themselves of the services of a small fish. They employed in the capture of turtle the Remora, once said to detain ships (probably the Echeneis Naucrates), called in Spanish "Reves," or reversed, because at first sight his back and abdomen are mistaken for each other. The remora attaches itself to the turtle by suction through the interstices of the indented and moveable cartilaginous plates which cover the head of the latter, and "would rather," says Columbus, "allow itself to be cut in pieces than lose its hold." The natives, therefore, attach a line, formed of palm fibres, to the tail of the little fish, and after it has fastened itself to the turtle draw both out of the water together. Martin Anghiera, the learned secretary of Charles V., says, "Nostrates piscem reversum appellant, quod versus venatur. Non aliter ac nos canibus gallicis per æquora campi lepores insectamur, illi (incolæ Cubæ insulæ) venatorio pisce pisces alios capiebant." (Petr. Martyr, Oceanica, 1532, Dec. I. p. 9; Gomara, Hist. de las Indias, 1553, fol. xiv.) We learn by Dampier and Commerson that this piscatorial artifice, the employing a sucking-fish to catch other inhabitants of the water, is much practised on the East Coast of Africa, at Cape Natal and on the Mozambique Channel, and also in the Island of Madagascar. (Lacépède, Hist. nat. des Poissons, T. i. p. 55.) The same necessities combine with a knowledge of the habits of animals to induce the same artifices and modes of capture among nations who are entirely unconnected with each other.

Although, as we have already remarked, the zone included between 22 or 24 degrees of latitude on either side of the equator, appears to be the true region of the calcareous saxigenous lithophytes which raise wall-like structures, yet coral reefs are also found, favoured it is supposed by the warm current of the Gulf-stream, in lat. 32° 23′, at the Bermudas, where they have been extremely well described by Lieutenant Nelson. (Transactions of the Geological Society, 2d Series, 1837, Vol. V. Pt. i. p. 103.) In the southern hemisphere, corals, (Millepores and Cellepores), are found singly as far south as Chiloe, the Archipelago of Chonos, and Tierra de Fuego, in 53° lat.; and Retepores are even found in lat. 72½°.

Since the second voyage of Captain Cook there have been many defenders of the hypothesis put forward by him as well as by Reinhold and George Forster, according to which the low coral islands of the Pacific have been built up by living creatures from the depths of the bottom of the sea. The distinguished investigators of nature, Quoy and Gaimard, who accompanied Captain Freycinet in his voyage round the world in the frigate Uranie, were the first who ventured, in 1823, to express themselves with great boldness and freedom in opposition to the views of the two Forsters (father and son), of Flinders, and of Péron. (Annales des Sciences Naturelles, T. vi., 1825, p. 273.)

"En appelant l'attention des naturalistes sur les animalcules des coraux, nous espérons démontrer que tout ce qu'on a dit ou cru observer jusqu'à ce jour relativement aux immenses travaux qu'il sont susceptibles d'exécuter, est le plus souvent inexact et toujours excessivement exagéré. Nous pensons que les coraux, loin d'élever des profondeurs de l'océan des murs perpendiculaires, ne forment que des couches ou des encroûtemens de quelques toises d'èpaisseur." Quoy and Gaimard also propounded (p. 289) the conjecture that the Atolls, (coral walls enclosing a lagoon), probably owed their origin to submarine volcanic craters. Their estimate of the depth below the surface of the sea at which the animals which form the coral reefs (the species of Astræa, for example) could live, was doubtless too small, being at the utmost from 25 to 30 feet (26½ to 32 E.) An investigator and lover of nature who has added to his own many and valuable observations a comparison with those of others in all parts of the globe, Charles Darwin, places with greater certainty the depth of the region of living corals at 20 to 30 fathoms. (Darwin, Journal, 1845, p. 467; and the same writer's Structure of Coral Reefs, p. 84-87; and Sir Robert Schomburgk, Hist. of Barbadoes, 1848, p. 636.) This is also the depth at which Professor Edward Forbes found the greatest number of corals in the Egean Sea: it is his "fourth region" of marine animals in his very ingenious memoir on the "Provinces of Depth" and the geographical distribution of Mollusca at vertical distances from the surface. (Report on Ægean Invertebrata in the Report of the 13th Meeting of the British Association, held at Cork in 1843, pp. 151 and 161.) The depths at which corals live would seem, however, to be very different in different species, and especially in the more delicate ones which do not form such large masses.

Sir James Ross, in his Antarctic Expedition, brought up corals with the sounding lead from great depths, and entrusted them to Mr. Stokes and Professor Forbes for more thorough examination. On the west of Victoria Land, near Coulman Island, in S. lat. 72° 31′, at a depth of 270 fathoms, Retepora cellulosa, a species of Hornera, and Prymnoa Rossii, were found quite fresh and living. Prymnoa Rossii is very analogous to a species found on the coast of Norway. (See Ross, Voyage of Discovery in the Southern and Antarctic Regions, vol. i. pp. 334 and 337.) In a similar manner in the high northern regions the whalers have brought up Umbellaria grænlandica, living, from depths of 236 fathoms. (Ehrenberg, in the Abhandl. der Berl. Akad. aus dem J. 1832, S. 430.) We find similar relations of species and situation among sponges, which, indeed, are now considered to belong rather to plants than to zoophytes. On the coasts of Asia Minor the common sponge is found by those engaged in the fishery at depths varying from 5 to 30 fathoms; whereas a very small species of the same genus is not found at a less depth than 180 fathoms. (Forbes and Spratt, Travels in Lycia, 1847, Vol. ii. p. 124.) It is difficult to divine the reason which prevents Madrepores, Meandrina, Astræa, and the entire group of tropical Phyto-corals which raise large cellular calcareous structures, from living in strata of water at a considerable depth below the surface of the sea. The diminution of temperature in descending takes place but slowly;

that of light almost equally so; and the existence of numerous Infusoria at great depths shews that the polypifers would not want for food.

In opposition to the hitherto generally received opinion of the entire absence of organic life in the Dead Sea, it is deserving of notice that my friend and fellow labourer, M. Valenciennes, has received through the Marquis Charles de l'Escalopier, and also the French consul Botta, fine specimens of Porites elongata from the Dead Sea. This fact is the more interesting because this species is not found in the Mediterranean, but belongs to the Red Sea, which, according to Valenciennes, has but few organic forms in common with the Mediterranean. I have before remarked that in France a sea fish, a species of Pleuronectes, advances far up the rivers into the interior of the country, thus becoming accustomed to gill-respiration in fresh water; so we find that the coral-animal above spoken of, the Porites elongata of Lamarck, has a not less remarkable flexibility of organisation, since it lives in the Dead Sea, which is over-saturated with salt, and in the open ocean near the Seychelle Islands. (See my Asie Centrale, T. ii. p. 517.)

According to the most recent chemical analyses made by the younger Silliman, the genus Porites, as well as many other cellular polypifers, (Madrepores, Andræas, and Meandrinas of Ceylon and the Bermudas), contain, besides 92-95 per cent. of carbonate of lime and magnesia, some fluoric and phosphoric acids. (See p. 124-131 of "Structure and Classification of Zoophytes," by James Dana, Geologist of the United States' Exploring Expedition, under the command of Captain Wilkes.) The presence of fluorine in the solid parts of polypifers reminds us of the fluorate of lime in the bones of fishes, according to the experiments of Morechini and Gay Lussac at Rome. Silex is only found mixed in very small quantity with fluorate and phosphate of lime in coral stocks; but a coral-animal allied to the Horn-coral, Gray's Hyalonema, has an axis of pure fibres of silex resembling a queue or braided tress of hair. Professor Forchhammer, who has been lately engaged in a thorough analysis of the sea-water from the most different parts of the globe, finds the quantity of lime in the Caribbean Sea remarkably small, being only 247 parts in ten thousand, while in the Categat it amounts to 371 parts in ten thousand. He is disposed to attribute this difference to the many coral-banks among the West Indian Islands, which appropriate the lime, and lower the per centage remaining in the sea-water. (Report of the 16th Meeting of the British Association for the Advancement of Science, held in 1846, p. 91.)

Charles Darwin has developed in a very ingenious manner the probable genetic connection between fringing or shore-reefs, island-encircling reefs, and lagoon-islands, *i. e.*, narrow ring-shaped reefs enclosing interior lagoons. According to his views these three varieties of form are dependent on the oscillating condition of the bottom of the sea, or on periodic elevations and subsidences. The hypothesis which has been several times put forward, according to which the closed ring or annular form of the coral-reefs in Atolls or Lagoon Islands marks the configuration of a submarine volcano, the structure having been raised on the margin of the crater, is opposed by their great dimensions, the diameters of many of them being 30, 40, and sometimes even 60 geographical miles. Our fire-emitting mountains have no such craters; and if we would compare the lagoon, with its submerged interior and narrow enclosing reef, to one of the annular mountains of the moon, we must not forget that those lunar mountains are not volcanoes, but wall-surrounded districts. According to Darwin, the process of formation is the following:—He supposes a mountainous island surrounded by a coral-reef, (a "fringing reef" attached to the shore), to undergo subsidence: the "fringing reef" which subsides with the island is continually restored to its level by the tendency of the coral-animals to regain the surface of the sea, and becomes thus, as the island gradually sinks and is reduced in size, first an "encircling reef" at some distance from the included islet, and subsequently, when the latter has entirely disappeared, an atoll. According to this view, in which islands are regarded as the culminating points of a submerged land, the relative positions of the different coral islands would disclose to us that which we could hardly learn by the sounding line, concerning the configuration of the land which was above the surface of the sea at an earlier epoch. The entire elucidation of this attractive subject, (to the connection of which with the migrations of plants and the diffusion of races of men attention was called at the commencement of the present note), can only be hoped for when inquirers shall have succeeded in obtaining greater knowledge than is now possessed of the depth and the nature of the rocks on which the lowest strata of the dead corals rest.

(8) p. 11.—"*Traditions of Samothrace.*"

Diodorus has preserved to us this remarkable tradition, the probability of which renders it in the eyes of the geologist almost equivalent to a historical certainty. The Island of Samothrace, formerly called also Æthiopea, Dardania, Leucania or Leucosia in the Scholiast to Apollonius Rhodius, and which was a seat of the ancient mysteries of the Cabiri, was inhabited by the remains of an ancient nation, several words of whose language were preserved to a later period in the ceremonies accompanying sacrifices. The situation of this island, opposite to the Thracian Hebrus and near the Dardanelles, renders it not surprising that a more detailed tradition of the catastrophe of the breaking forth of the waters of the Euxine should have been preserved there. Rites were performed at altars supposed to mark the limits of the irruption of the waves; and in Samothrace as well as in Bœotia, a belief in the periodically recurring destruction of mankind, (a belief which was also found among the Mexicans in the form of a myth of four destructions of the world), was connected with historical recollections of particular inundations. (Otfr. Müller Geschichten Hellenischer Stämme und Städte, Bd. i. S. 65 and 119.) According to Diodorus, the Samothracians related that the Black Sea had once been an inland lake, but that, being swollen by the rivers which flow into it, it had broken through, first the strait of the Bosphorus, and afterwards that of the Hellespont; and this long before the inundations spoken of by other nations. (Diod. Sicul. lib. v. cap. 47, p. 369, Wesseling.) These ancient revolutions of nature have been treated of in a special work by Dureau de la Malle, and all the information possessed on the subject has been collected in Carl von Hoff's important work, entitled Geschichte der natürlichen Veränderungen der Erdoberfläche, Th. i. 1822, S. 105-162; and in Creuzer's Symbolik, 2te Aufl. Th. ii. S. 285, 318, and 361. A reflex, as it were, of the traditions of Samothrace appears in the "Sluice theory" of Strato of Lampsacus, according to which the swelling of the waters of the Euxine first opened the passage of the Dardanelles, and afterwards caused the outlet through the pillars of Hercules. Strabo has preserved to us in the first book of his Geography, among critical extracts from the works of Eratosthenes, a remarkable fragment of the lost writings of Strato, presenting views which extend to almost the entire circumference of he Mediterranean.

"Strato of Lampsacus," says Strabo (Lib. i. p. 49 and 50, Casaub.), "is even more disposed than the Lydian Xanthus," (who had described impressions of shells at a distance from the sea) "to expound the causes of the things which we see. He asserts that the Euxine had formerly no outlet at Byzantium, but the sea becoming swollen by the rivers which ran into it, had by its pressure opened the passage through which the waters flow into the Propontis and the Hellespont. He also says that the same thing has happened to our Sea (the Mediterranean);" "for here, too, when the sea had become swollen by the rivers, (which in flowing into it had left dry their marshy banks), it forced for itself a passage through the isthmus of land connecting the

Pillars. The proofs which Strato gives of this are, first that there is still a bank under water running from Europe to Libya, shewing that the outer and inner seas were formerly divided; and next that the Euxine is the shallowest, the Cretan, Sicilian, and Sardoic Seas being on the contrary very deep; the reason being that the Euxine has been filled with mud by the many and large rivers flowing into it from the North, while the other seas continued deep. The Euxine is also the freshest, and the waters flow towards the parts where the bottom of the sea is lowest. Hence he inferred that the whole of the Euxine would finally be choked with mud if the rivers were to continue to flow into it: and this is already in some degree the case on the west side of the Euxine towards Salmydessus (the Thracian Apollonia), and at what are called by mariners the "Breasts" off the mouth of the Ister and along the shore of the Scythian Desert. Perhaps the Temple of Ammon (in Lybia) may once have stood on the sea-shore, and causes such as these may explain why it is now far inland. This Strato thought might account for the celebrity of the Oracle, which would be less surprising if it had been on the sea-shore; whereas its great distance from the coast made its present renown inexplicable. Egypt, too, had been formerly overflowed by the sea as far as the marshes of Pelusium, Mount Casius, and Lake Serbonis; for, on digging beneath the surface, beds of sea-sand and shells are found; shewing that the country was formerly overflowed, and the whole district round Mount Casius and Gerrha was a marshy sea which joined the gulf of the Red Sea. When our Sea (the Mediterranean) retreated, the land was uncovered; still, however, leaving the Lake of Serbonis: subsequently this lake also broke through its bounds and the water flowed off, so that the lake became a swamp. The banks of Lake Mœris are also more like sea than river banks." An erroneously corrected reading introduced by Grosskurd on account of a passage in Strabo, Lib. xvii. p. 809, Cas., gives instead of Mœris "the Lake Halmyris:" but this latter lake was situated not far from the mouth of the Danube.

The sluice-theory of Strato led Eratosthenes of Cyrene (the most celebrated of the series of librarians of Alexandria, but less happy than Archimedes in writing on floating bodies), to examine the problem of the equality of level of all external seas, *i. e.*, seas surrounding the Continents. (Strabo, Lib. i. p. 51-56; Lib. ii. p. 104, Casaub). The varied outlines of the northern shores of the Mediterranean, and the articulated form of the peninsulas and islands, had given occasion to the geognostical myth of the ancient land of Lyctonia. The supposed mode of origin of the smaller Syrtis and of the Triton Lake (Diod. iii. 53-55) as well as that of the whole Western Atlas (Maximus Tyrius, viii. 7) were drawn in to form part of an imaginary scheme of igneous eruptions and earthquakes. (See my Examen crit. de l'hist. de la Géographie, Vol. i. p. 179; T. iii. p. 136.) I have recently touched more in detail on this subject (Kosmos, Bd. ii. S. 153; Engl. ed. p. 118-119) in a passage which I permit myself to subjoin:—

"A more richly varied and broken outline gives to the northern shore of the Mediterranean an advantage over the southern or Lybian shore, which according to Strabo was remarked by Eratosthenes. The three great peninsulas, the Iberian, the Italian, and the Hellenic, with their sinuous and deeply indented shores, form, in combination with the neighbouring islands and opposite coasts, many straits and isthmuses. The configuration of the continent and the islands, the latter either severed from the main or volcanically elevated in lines, as if over long fissures, early led to geognostical views respecting eruptions, terrestrial revolutions, and overpourings of the swollen higher seas into those which were lower. The Euxine, the Dardanelles, the Straits of Gades, and the Mediterranean with its many islands, were well fitted to give rise to the view of such a system of sluices. The Orphic Argonaut, who probably wrote in Christian times, wove antique legends into his song; he describes the breaking up of the ancient Lyktonia into several islands, when 'the dark-haired Poseidon, being wroth with Father Kronion, smote Lyktonia with the golden trident.' Similar phantasies, which indeed may often have arisen from imperfect knowledge of geographical circumstances, proceeded from the Alexandrian school, where erudition abounded, and a strong predilection was felt for antique legends. It is not necessary to determine here whether the myth of the Atlantis broken into fragments should be regarded as a distant and western reflex of that of Lyktonia (as I think I have elsewhere shewn to be probable), or whether, as Otfried Müller considers, "the destruction of Lyktonia (Leuconia) refers to the Samothracian tradition of a great flood which had changed the form of that district."

(9) p. 12.—"*Prevents precipitation taking place from clouds.*"

The vertically-ascending current of the atmosphere is a principal cause of many most important meteorological phenomena. When a desert or a sandy plain partly or entirely destitute of plants is bounded by a chain of high mountains, we see the sea breeze drive the dense clouds over the desert without any precipitation taking place before they have reached the mountain-ridge. This phenomenon was formerly explained in a very inappropriate manner by a supposed superior attraction exercised by the mountains on the clouds. The true reason of the phenomenon appears to consist in the ascending column of warm air which rises from the sandy plain, and prevents the vesicles of vapour from being dissolved. The more complete the absence of vegetation, and the more the sand is heated, the greater is the height of the clouds, and the less can any fall of rain take place. When the clouds reach the mountains these causes cease to operate; the play of the vertically-ascending atmospheric current is feebler, the clouds sink lower, and dissolve in rain in a cooler stratum of air. Thus, in deserts, the *want of rain*, and the *absence of vegetation*, act and react upon each other. It does not rain, because the naked sandy surface having no vegetable covering, becomes more powerfully heated by the solar rays, and thus radiates more heat; and the absence of rain forbids the desert being converted into a steppe or grassy plain, because without water no organic development is possible.

(10) p. 14.—"*The mass of the earth in solidifying and parting with its heat.*"

If, according to the hypothesis of the Neptunists, now long since obsolete, the so-called primitive rocks were precipitated from a fluid, the transition of the crust of the earth from a fluid to a solid state must have been accompanied by an enormous disengagement of heat, which would in turn have caused fresh evaporation and fresh precipitations. The later these precipitations, the more rapid, tumultuous, and uncrystalline they would have been. Such a sudden disengagement of heat *might* cause local augmentations of temperature independent of the height of the pole or the latitude of the place, and independent of the position of the earth's axis; and the temperatures thus caused would influence the distribution of plants. The same sudden disengagement of heat might also occasion a species of porosity, of which there seem to be indications in many enigmatical geological phenomena in sedimentary rocks. I have developed these conjectures in detail in a small memoir "über ursprungliche Porosität." (See my work entitled Versuche über die chemische Zersetzung des Luftkreises, 1799, S. 177; and Moll's Jahrbücher der Berg- und Hüttenkunde, 1797, S. 234.) According to the newer views which I now entertain, the shattered and fissured earth, with her molten interior, may long have maintained a high temperature on her oxydised surface, independently of position in respect to the sun and of latitude. Would not the climate of Germany be wonderfully altered, and that perhaps for centuries, if there were opened a fissure a thousand fathoms in depth, reaching from the shores of the Adriatic to the Baltic? If in the present condition of our planet, the stable equilibrium of temperature, first calculated by Fourier in his Théorie analytique de la chaleur, has been almost completely restored by radiation from the earth into space; and if the external atmosphere now only communicates with the molten interior through the inconsiderable openings of a few volcanoes,—in the earlier state of things numerous clefts and fissures, produced by the frequently recurring corrugations of the rocky strata of the globe, emitted streams of heated air which mingled with the atmosphere and were entirely independent of latitude. Every planet must thus in its earliest condition have for a time determined its own temperature, which afterwards becomes dependent on the position relatively to the central body, the Sun. The surface of the Moon also shows traces of this reaction of the interior upon the crust.

(11) p. 14.—"*The mountain declivities of the southern part of Mexico.*"

The greenstone in globular concretions of the mountain district of Guanaxuato is quite similar to that of the Franconian Fichtel-Gebirge. Both form grotesquely shaped summits, which pierce through and cover the transition argillaceous schists. In the same manner, pearl stone, porphyritic schists, trachyte, and pitch-stone porphyry, constitute rocks similar in form in the Mexican mountains near Cinapecuaro and Moran, in Hungary, in Bohemia, and in Northern Asia.

(12) p. 16.—"*The dragon-tree of Orotava.*"

This colossal dragon-tree, Dracæna draco, stands in the garden of Dr. Franqui in the small town of Oratava, the ancient Taoro, one of the most delightful spots in the world. In June 1799, when we ascended the Peak of Teneriffe, we measured the circumference of the tree, and found it nearly 48 English feet. Our measurement was taken several feet above the root. Lower down, and nearer to the ground, Le Dru made it nearly 79 English feet. Sir George Staunton found the diameter still as much as 12 feet at the height of 10 feet above the ground. The height of the tree is not much above 69 English feet. According to tradition, this tree was venerated by the Guanches (as was the ash-tree of Ephesus by the Greeks, or as the Lydian plane-tree which Xerxes decked with ornaments, and the sacred Banyan-tree of Ceylon), and at the time of the first expedition of the Béthencourts in 1402, it was already as thick and as hollow as it now is. Remembering that the Dracæna grows extremely slowly, we are led to infer the high antiquity of the tree of Orotava. Bertholet, in his description of Teneriffe, says, "En comparant les jeunes Dragonniers, voisins de l'arbre gigantesque, les calculs qu'on fait sur l'age de ce dernier effraient l'imagination." (Nova Acta Acad. Leop. Carol. Naturæ Curiosorum, T. xiii. 1827, p. 781.) The dragon-tree has been cultivated in the Canaries, and in Madeira and Porto Santo, from the earliest times; and an accurate observer, Leopold von Buch, has even found it wild in Teneriffe, near Igueste. Its original country, therefore, is not India, as had long been believed; nor does its appearance in the Canaries contradict the opinion of those who regard the Guanches as having been an isolated Atlantic nation without intercourse with African or Asiatic nations. The form of the Dracænas is repeated at the southern extremity of Africa, in the Isle of Bourbon, and in New Zealand. In all these distant regions species of the genus in question are found, but none have been met with in the New Continent, where its form is replaced by that of the Yucca. Dracæna borealis of Aiton is a true Convallaria, and has all the "habitus" of that genus. (Humboldt, Rel. hist. T. i. p. 118 and 639.) I have given a representation of the dragon-tree of Orotava, taken from a drawing made by F. d'Ozonne in 1776, in the last plate of the Picturesque Atlas of my American journey. (Vues des Cordillères et Monumens des Peuples indigènes de l'Amérique, Pl. lxix.) I found d'Ozonne's drawing among the manuscripts left by the celebrated Borda, in the still unprinted travelling journal entrusted to me by the Dépôt de la Marine, and from which I borrowed important astronomically-determined geographical, as well as barometric and trigonometric notices. (Rel. hist. T. i. p. 282.) The measurement of the dragon-tree of the Villa Franqui was made on Borda's first voyage with Pingré, in 1771; not in his second voyage, in 1776, with Varela. It is affirmed that in the early times of the Norman and Spanish Conquests, in the 15th century, Mass was said at a small altar erected in the hollow trunk of the tree. Unfortunately the dragon-tree of Orotava lost one side of its top in the storm of the 21st of July, 1819. There is a fine and large English copperplate engraving which represents the present state of the tree with remarkable truth to nature.

The monumental character of these colossal living vegetable forms, and the kind of reverence which has been felt for them among all nations, have occasioned in modern times the bestowal of greater care in the numerical determination of their age and the size of their trunks. The results of these inquiries have led the author of the important treatise, “De la longévité des Arbres,” the elder Decandolle, Endlicher, Unger, and other able botanists, to consider it not improbable that the age of several individual trees which are still alive goes back to the earliest historical periods, if not of Egypt, at least of Greece and Italy. It is said in the Bibliothèque Universelle de Genève, 1831, T. lxvii. p. 50:—“Plusieurs exemples semblent confirmer l'idée qu'il existe encore sur le globe des arbres d'une antiquité prodigieuse, et peut-être témoins de ses dernières révolutions physiques. Lorsqu'on regarde un arbre comme un agrégat d'autant d'individus soudés ensemble qu'il s'est développé de bourgeons à sa surface, on ne peut pas s'étonner si, de nouveaux bourgeons s'ajoutant sans cesse aux anciens, l'agrégat qui en résulte n'a point de terme nécessaire à son existence.” In the same manner Agardh says:—“If in trees there are produced in each solar year new parts, so that the older hardened parts are replaced by new ones capable of conducting sap, we see herein a type of growth limited only by external causes.” He ascribes the shortness of the life of herbs, or of such plants as are not trees, “to the preponderance of the production of flowers and fruit over the formation of leaves.” Unfruitfulness is to a plant a prolongation of life. Endlicher cites the example of a plant of Medicago sativa, var. β versicolor, which, bearing no fruit, lived eighty years. (Grundzüge der Botanik, 1843, S. 1003).

With the dragon trees, which, notwithstanding the gigantic development of their closed vascular bundles, must by reason of their floral parts be placed in the same natural family with asparagus and garden onions, we must associate the Adansonia (monkey bread-tree, Baobab,) as being certainly among the largest and oldest inhabitants of our planet. In the very first voyages of discovery of the Catalans and Portuguese, the navigators were accustomed to cut their names on these two species of trees, not merely to gratify the desire of handing down their names, but also to serve as marks or signs of possession, and of whatever rights nations claim on the ground of being the first discoverers. The Portuguese navigators often used as their "marco" or token of possession the French motto of the Infant Don Henrique the Discoverer. Manuel de Faria y Sousa says in his Asia Portuguesa (T. i. cap. 2, pp. 14 and 18) :—"Era uso de los primeros Navegantes de dexar inscrito el Motto del Infante, *talent de bien faire,* en la corteza de los arboles." (Compare also Barros, Asia, Dec. I. liv. ii. cap. 2, T. i. p. 148; Lisboa, 1778.)

The above-named motto cut on the bark of two trees by Portuguese navigators in 1435, twenty-eight years therefore before the death of the Infante, is curiously connected in the history of discoveries with the elucidations to which the comparison of Vespucci's fourth voyage with that of Gonzalo Coelho, in 1503, has given rise. Vespucci relates that Coelho's admiral's ship was wrecked on an island which has been sometimes supposed to be San Fernando Noronha, sometimes the Peñedo de San Pedro, and sometimes the problematical Island of St. Matthew. This last-named island was discovered by Garcia Jofre de Loaysa on the 15th of October, 1525, in 2½° S. lat., in the meridian of Cape Palmas, almost in the Gulf of Guinea. He remained there eighteen days at anchor, found crosses, as well as orange trees which had been planted and had become wild, and on two trunks of trees inscriptions dating back ninety years. (Navarrete, T. v. pp. 8, 247, and 401.) I have examined the questions presented by this account more in detail in my inquiries into the trustworthiness of Amerigo Vespucci. (Examen critique de l'hist. de la Geographie, T. v. pp. 129-132.)

The oldest description of the Baobab (Adansonia digitata), is that given by the Venetian Aloysius Cadamosto (the real name was Alvise da Ca da Mosto), in 1454. He found at the mouth of the Senegal, trunks of which he estimated the circumference at seventeen fathoms, or 102 feet, (Ramusio, Vol. i. p. 109): he might have compared them with Dragon trees which he had seen before. Perrottet says in his "Flore de Sénégambie" (p. 76), that he had seen monkey bread-trees which, with a height of only about 70 or 80 feet, had a diameter of 32 English feet. The same dimensions had been given by Adanson, in the account of his voyage in 1748; the largest trunks which he himself saw (in 1749) in one of the small Magdalena islands near Cape de Verd, and in the vicinity of the mouth of the Senegal River, were from 26 to 28½ English feet in diameter, with a height of little more than 70 feet, and a top about 180 feet broad;

but he adds at the same time, that other travellers had found trunks of nearly 32 English feet diameter. French and Dutch sailors had cut their names on the trees seen by Adanson in letters half a foot long; the dates added to the names shewed these inscriptions to be all of the 16th century, except one which belonged to the 15th. (In Adanson's "Familles des Plantes," 1763, P. I. pp. ccxv.-ccxviii., it stands as the 14th century, but this is doubtless an error of inadvertence.) From the depth of the inscriptions, which were covered with new layers of wood, and from the comparison of the thickness of different trunks of the same species in which the relative age of the trees was known, Adanson computed the probable age of the larger trees, and found for a diameter of 32 English feet 5150 years. (Voyage au Sénegal, 1757, p. 66.) He prudently adds (I do not alter his curious orthography):—"Le calcul de l'aje de chake couche n'a pas d'exactitude géometrike." In the village of Grand Galarques, also in Senegambia, the negroes have ornamented the entrance of a hollow Baobab tree with sculptures cut out of the still fresh wood; the interior serves for holding meetings in which their interests are debated. Such a hall of assembly reminds one of the hollow or cave (specus) of the plane tree in Lycia, in which Lucinius Mutianus, who had previously been consul, feasted with twenty-one guests. Plino (xii. 3) assigns to such a cavity in a hollow tree the somewhat large allowance of a breadth of eighty Roman feet. The Baobab was seen by Réné Caillié in the Valley of the Niger near Jenne, by Caillaud in Nubia, and by Wilhelm Peters along the whole eastern coast of Africa (where it is called Mulapa, *i. e.* Nlapa-tree, more properly Muti-nlapa) as far as Lourenzo Marques, almost to 26° of S. lat. Although Cadamosto said in the 15th century "eminentia non quadrat magnitudini," and although Golberry (Fragmens d'un Voyage en Afrique, T. ii. p. 92) found in the "Vallée des deux Gagnacks" trunks which, with 36 English feet diameter near the roots, were only 64 English feet high, yet this great disproportion between height and thickness must not be regarded as general. The learned traveller Peters remarks that "very old trees lose height by the gradual decay of the top, while they continue to increase in girth. On the East Coast of Africa one sees not unfrequently trunks of little more than ten feet diameter reach a height of 69 English feet."

If, according to what has been said, the bold estimations of Adanson and Perottet assign to the Adansonias measured by them an age of from 5150 to 6000 years, which would make them contemporaneous with the epoch of the building of the Pyramids or even with that of Menes, a period when the constellation of the Southern Cross was still visible in Northern Germany (Kosmos, Bd. iii. S. 402 and 487; Eng. ed. p. 293, and note 146), on the other hand, the more secure estimations made from the annual rings of trees in our northern temperate zone, and from the ratio which has been found to subsist between the thickness of the layer of wood and the time of growth, give us shorter periods. Decandolle finds as the result of his inquiries, that of all European species of trees the yew is that which attains the greatest age. He assigns to the yew (Taxus baccata) of

Braborne, in the county of Kent, thirty centuries; to the Scotch yew of Fortingal, from twenty-five to twenty-six; and to those of Crowhurst in Surrey, and Ripon in Yorkshire, respectively, fourteen and a half and twelve centuries. (Decandolle, de la longévité des arbres, p. 65.) Endlicher remarks that the age of another yew tree, in the Churchyard of Grasford, in North Wales, which measures 52 English feet in circumference below the branches, is estimated at 1400 years, and that of a yew in Derbyshire at 2096 years. In Lithuania lime trees have been cut down which were 87 English feet in circumference, and in which 815 annual rings have been counted." (Endlicher, Grundzüge der Botanik, S. 399.) In the temperate zone of the southern hemisphere some species of Eucalyptus attain an enormous girth, and as they also reach to a great stature (above 230 Paris, 245 English, feet), they are singularly contrasted with our yew trees, whose great dimension is in thickness only. Mr. Backhouse found in Emu Bay, on the coast of Van Diemen Land, trunks of Eucalyptus which measured 70 English feet round the trunk near the ground, and five feet higher up 50 English feet. (Gould, Birds of Australia, Vol. I. Introd. p. xv.)

It is not, as is commonly stated, Malpighi, but the ingenious Michel Montaigne, who has the merit of having been the first, in 1581, in his Voyage en Italie, to notice the relation of the annual rings to the age of the tree. (Adrien de Jussieu, Cours élémentaire de Botanique, 1840, p. 61.) A skilful artist, engaged in the preparation of astronomical instruments, had called the attention of Montaigne to the annual rings; and he also maintained that the rings were narrower on the north side of the tree. Jean Jacques Rousseau had the same belief; and his Emile, if he loses himself in a forest, is to direct himself by the indications afforded by the relative thickness of the layers of wood. More recent observations on the anatomy of plants teach us, however, that both the acceleration and also the retardation or intermission of growth, or the varying production of circles of ligneous fascicles (annual deposits) from the Cambium cells, depend on influences which are wholly distinct from the quarter of the heavens towards which one side of the annual rings is turned. (Kunth, Lehrbuch der Botanik, 1847, T. i. S. 146 and 164; Lindley, Introduction to Botany, 2d edition, p. 75.)

Trees which in individual cases attain a diameter of more than twenty feet, and an age extending to many centuries, belong to the most different natural families. I may name here Baobabs, Dragon-trees, some species of Eucalyptus, Taxodium disticum (Rich.), Pinus Lambertiana (Douglas), Hymenæa courbaril, Cæsalpinieæ, Bombax, Swietenia mahagoni, the Banyan tree (Ficus religiosa), Liriodendron tulipifera? Platanus orientalis, and our Limes, Oaks, and Yews. The celebrated Taxodium distichon, the Ahuahuete of the Mexicans, (Cupressus disticha Linn., Schubertia disticha Mirbel); at Santa Maria del Tule, in the state of Oaxaca, has not a diameter of 57, as Decandolle says, but of exactly 38 French (40½ English) feet. (Mühlenpfordt, Versuch einer getreuen Schilderung der Republik Mexico, Bd. i. S. 153.) The two fine Ahuahuetes near Chapoltepec, which I have often seen, and which are probably the surviving remnants of an ancient garden or pleasure-ground of Montezuma, measure, (according to Burkart's account of his travels, Bd. i. S. 268, a work which otherwise contains much information), only 36 and 38 English feet in circumference; not in diameter, as has often been erroneously asserted. The Buddhists in Ceylon venerate the gigantic trunk of the sacred fig-tree of Anourahdepoura. The Indian fig-tree or Banyan, of which the branches take root round the parent stem, forming, as Onesicritus well described, a leafy canopy resembling a many-pillared tent, often attain a thickness of 28 (29½ English) feet diameter. (Lassen, Indische Alterthumskunde, Bd. i. S. 260.) On the Bombax ceiba, see early notices of the time of Columbus, in Bembo's Historiæ Venetæ, 1551, fol. 83.

Among oak-trees, of those which have been accurately measured, the largest in Europe is no doubt that near the town of Saintes, in the Departement de la Charente Inférieure, on the road to Cozes. This tree, which is 60 (64 English) feet high, has a diameter of 27 feet 8½ inches (29½ English feet) near the ground; 21½ (almost 23 English) feet five feet higher up; and where the great boughs commence 6 Parisian feet (6 feet 5 inches English.) In the dead part of the trunk a little chamber has been arranged, from 10 feet 8 inches to 12 feet 9 inches wide, and 9 feet 8 inches high (all English measure), with a semi-circular bench cut out of the fresh wood. A window gives light to the interior, so that the sides of the chamber (which is closed with a door) are clothed with ferns and lichens, giving it a pleasing appearance. Judging by the size of a small piece of wood which has been cut out above the door, and in which the marks of 200 annular rings have been counted, the oak of Saintes would be between 1800 and 2000 years old. (Annales de la Société d'Agriculture de la Rochelle, 1843, p. 380.)

In the wild rose-tree of the crypt of the Cathedral of Hildesheim, said to be a thousand years old, it is the root only, and not the stem, which is eight centuries old, according to accurate information derived from ancient and trustworthy original documents, for the knowledge of which I am indebted to the kindness of Stadtgerichts-Assessor Römer. A legend connects the rose-tree with a vow made by the first founder of the cathedral, Ludwig the Pious; and an original document of the 11th century says, "that when Bishop Hezilo rebuilt the cathedral which had been burnt down, he enclosed the roots of the rose-tree with a vault which still exists, raised upon this vault the crypt, which was re-consecrated in 1061, and spread out the branches of the rose-tree upon the walls." The stem now living is 26½ feet high and about two inches thick, and the outspread branches cover about 32 feet of the external wall of the eastern crypt; it is doubtless of considerable antiquity, and well deserving of the celebrity which it has gained throughout Germany.

If extraordinary development in point of size is to be regarded as a proof of long continued organic life, particular attention is due to one of the thalassophytes of the sub-marine vegetable world, *i. e.*, to the Fucus giganteus, or Macrocystis pyrifera of Agardh. According to Captain Cook and George Forster, this sea-plant attains a length of 360 English feet; surpassing, therefore, the height of the loftiest Coniferæ, even that of the Sequoia gigantea, Endl., or Taxodium sempervirens, Hook and Arnott, which grows in California. (Darwin, Journal of Researches into Natural History, 1845, p. 239; and Captain Fitz-Roy in the Narrative of the Voyages of the Adventure and Beagle, vol. ii. p. 363.) Macrocystis pyrifera is found from 64° south to 45° north latitude, as far as San Francisco on the north-west coast of America; and Joseph Hooker believes it to extend as far as Kamtschatka. In the Antarctic seas it is even seen floating among the pack-ice. (Joseph Hooker, Botany of the Antarctic Voyage under the command of Sir James Ross, 1844, pp. 7, 1, and 178; Camille Montagne, Botanique cryptogame du Voyage de la Bonite, 1846, p. 36.) The immense length to which the bands or ribbands and the cords or lines of the cellular tissue of the Macrocystis attain, appears to be limited only by accidental injuries.

(13) p. 17.—"*Species of phænogamous plants already contained in herbariums.*"

We must carefully distinguish between three different questions: How many species of plants are described in printed works? how many have been discovered, *i. e.* are contained in herbariums, though without being described? how many are probably existing on the globe? Murray's edition of the Linnean system contains, including cryptogamia, only 10042 species. Willdenow, in his edition of the Species Plantarum, between the years 1797 and 1807, had already described 17457 phænogamous species, (from Monandria to Polygamia diœcia.) If we add 3000 cryptogamous species, we obtain the number which Willdenow mentions, viz. 20000 species. More recent researches have shown how much this estimation of the number of species described and contained in herbariums falls short of the truth. Robert Brown counted above 37000 phænogamous plants. (General Remarks on the Botany of Terra Australis, p. 4.) I afterwards attempted to give the geographical distribution (in different parts of the earth already explored), of 44000 phænogamous and cryptogamous plants. (Humboldt, de distributione geographica Plantarum, p. 23.) Decandolle found, in comparing Persoon's Enchiridium with his Universal System in 12 several families, that the writings of botanists and European herbariums taken together might be assumed to contain upwards of 56000 species of plants. (Essai élementaire de Géographie botanique, p. 62.) If we consider how many species have since that period been described by travellers,—(my expedition alone furnished 3600 of the 5800 collected species of the equinoctial zone),—and if we remember that in all the botanical gardens taken together there are certainly above 25000 phænogamous plants cultivated, we shall easily perceive how much Decandolle's number falls short of the truth. Completely unacquainted as we still are with the larger portions of the interior of South America,—(Mato-Grosso, Paraguay, the eastern declivity of the Andes, Santa Cruz de la Sierra, and all the countries between the Orinoco, the Rio Negro, the Amazons, and Puruz),—of Africa, Madagascar, Borneo, and Central and Eastern Asia,—the thought rises involuntarily in the mind that we may not yet know the third, or probably even the fifth part of the plants existing on the earth! Drège has collected 7092 species of phænogamous plants in South Africa alone. (See Meyer's pflanzen geographische Documente, S. 5 and 12.) He believes that the Flora of that district consists of more than 11000 phænogamous species, while on a surface of equal area (12000 German, or 192000 English square geographical miles) von Koch has described in Germany or Switzerland 3300, and Decandolle in France 3645 species of phænogamous plants. I would also recall that even now new Genera, (some even consisting of tall forest trees), are being discovered in the small West Indian Islands which have been visited by Europeans for three centuries, and in the vicinity of large commercial towns. These considerations, which I propose to develop in further detail at the close of the present annotation, make it probable that the actual number of species exceeds that spoken of in the old myth of the Zend-Avesta, which says that "the Primeval Creating Power called forth from the blood of the sacred bull 120000 different forms of plants!"

If, then, we cannot look for any direct scientific solution of the question of how many forms of the vegetable kingdom,—including leafless Cryptogamia (water Algæ, funguses, and lichens), Characeæ, liver-worts, mosses, Marsilaceæ, Lycopodiaceæ, and ferns,—exist on the dry land and in the ocean in the present state of the organic life of our globe, we may yet attempt an approximate method by which we may find some probable "lowest limits" or numerical minima. Since 1815, I have sought, in arithmetical considerations relating to the geography of plants, to examine first the ratios which the number of species in the different natural families bear to the entire mass of the phænogamous vegetation in countries where the latter is sufficiently well known. Robert Brown, the greatest botanist among our cotemporaries, had previously determined the numerical proportions of the leading divisions of the vegetable kingdom ; of Acotyledons (Agamæ, Cryptogamic or cellular plants) to Cotyledons (Phanerogamic or vascular plants), and of Monocotyledonous (Endogenous) to Dicotyledonous (Exogenous) plants. He finds the ratio of Monocotyledons to Dicotyledons in the tropical zone as 1 : 5, and in the cold zones of the parallels of 60° N. and 55° S. latitude, as 1 : 2½. (Robert Brown, General Remarks on the Botany of Terra Australis, in Flinders' Voyage, vol. ii. p. 338.) The absolute number of species in the three leading divisions of the vegetable kingdom are compared together in that work according to the method there laid down. I was the first to pass from these leading divisions to the divisions of the several families, and to consider the ratio which the number of species of each family bears to the entire mass of phænogamous plants belonging to a zone of the earth's surface. (Compare my memoir entitled "De distributione geographica Plantarum secundum cœli temperiem et altitudinem montium, 1817, p. 24-44 ; and the farther development of the subject of these numerical relations given by me in the Dictionnaire des Sciences naturelles, T. xviii. 1820, p. 422-436; and in the Annales de Chimie et de Physique, T. xvi. 1821, p. 267-292.)

The numerical relations of the forms of plants, and the laws observed in their geographical distribution, may be considered in two very different ways. If plants are studied in their arrangement according to natural families, without regard to their geographical distribution, it is asked, What are the fundamental forms or types of organisation to which the greatest number of species correspond? Are there on the entire surface of the earth more Glumaceæ than Compositæ? Do these two orders make up between them one-fourth part of the whole number of phænogamous plants? What is the proportion of Monocotyledons to Dicotyledons? These are questions of General Phytology, or of the science which investigates the organisation of plants and their mutual connection, or the present state of the entire vegetable world.

If, on the other hand, the species of plants which have been grouped according to the analogy of their structure are considered, not abstractedly, but according to their climatic relations, or according to their distribution over the surface of the earth, we have questions offering quite another and distinct interest. We then examine what are the families which prevail more in proportion to other Phanerogamæ in the torrid zone than towards the polar circle? Are Compositæ more numerous, either in the same geographical latitudes or on the same isothermal lines, in the New than in the Old Continent? Do the forms which gradually lose their predominance in advancing from the equator towards the poles follow a similar law of decrease in ascending mountains situated in the equatorial regions? Do the proportions of particular families to the whole mass of Phanerogamæ differ in the temperate zones, and on equal isothermal lines, north and south of the equator? These questions belong properly to the Geography of Plants, and connect themselves with the most important problems of meteorology and terrestrial physics. The character of a landscape or country is also in a high degree dependent on the predominance of particular families of plants, which render it either desolate or adorned, smiling or majestic. Grasses forming extensive savannahs, Palms and other trees affording food, or social Coniferæ forming forests, have powerfully influenced nations in respect to their material condition, to their manners, to their mental dispositions, and to the more or less rapid development of their prosperity.

In studying the geographical distribution of forms, we may consider species, genera, and natural families, separately. In social plants, a single species often covers extensive tracts of country; as in northern regions forests of Pines or Firs and extensive heaths (ericeta), in Spain cistus-covered grounds, and in tropical America assemblages of the same species of Cactus, Croton, Brathys, or Bambusa Guadua. It is interesting to examine these relations more closely, and to view in one case the great multiplicity of individuals, and in another the variety of organic development. We may inquire what species produces the greatest number of individuals in a particular zone, or we may ask which are the families to which, in different climates, the greatest number of species belong. In a high northern region, where the Compositæ and the Ferns are to the sum of all the phænogamous plants in the ratio of 1 : 13 and 1 : 25 (*i. e.* where these ratios are found by dividing the sum total of all the Phanerogamæ by the number of species belonging to the family of Compositæ or to that of Filices or Ferns), it may nevertheless happen that a single species of fern covers ten times more ground than do all the species of Compositæ taken together. In this case Ferns predominate over Compositæ by their mass, or by the number of individuals belonging to the same species of Pteris or Polypodium; but they do not so predominate if we only compare the number of the different specific forms of Filices and Compositæ with the sum of all the phænogamous plants. Since, then, multiplication of plants does not follow the same law in all species,—that is to say, all species do not produce the same number of individuals,—therefore the quotients given by dividing the sum of the phænogamous plants by the number of species belonging to one family, do not suffice by themselves to determine the character of the landscape, or the physiognomy which Nature assumes in different regions of the earth. If the attention of the travelling botanist is engaged by the frequent repetition of the same species, their mass, and the uniformity of vegetation thus produced, it is even more arrested by the rarity or infrequency of several other species which are valuable to mankind. In tropical regions, where the Rubiaceæ, Myrtaceæ, Leguminosæ, or Terebinthaceæ, form forests, one is astonished to find the trees of Cinchona, particular species of Swietenia (Mahogany), Hæmatoxylon, Styrax, and balsamic Myroxylum, so sparingly distributed. We had occasion, on the declivities of the high plains of Bogota and Popayan, and in the country round Loxa, in descending towards the unhealthy valley of the Catamayo and to the Amazons River, to remark the manner in which the trees which furnish the precious fever-bark (species of Cinchona) are found singly and at considerable distances from each other. The China Hunters, Cazadores de Cascarilla (the name given at Loxa to the Indians and Mestizoes who collect each year the most efficacious of all fever-barks, that of the Cinchona Condaminea, among the lonely mountains of Caxanuma, Uritusinga, and Rumisitana), climb, not without peril, to the summits of the loftiest forest trees in order to gain a wide prospect, and to discern the solitarily scattered slender aspiring trunks of the trees of which they are in search, and which they recognise by the shining reddish tint of their large leaves. The mean temperature of this important forest region, situated in 4° to 4½° S. lat. and at an elevation of about 6400 to 8000 English feet, is from 12½° to 16° Réaumur (60°·2 to 68° Fahr.) (Humboldt and Bonpland, Plantes équinoxiales, T. i. p. 33, tab. 10.)

In considering the distribution of species, we may also proceed, without regard to the multiplication of individuals, to the masses which they form or the space which they occupy, and may simply compare together the absolute number of species belonging to a particular family in each country. This is the mode of comparison which Decandolle has employed in the work entitled Regni vegetabilis Systema naturale (T. i. p. 128, 396, 439, 464, and 510), and Kunth has carried it out in regard to the whole number of species of Compositæ at present known (above 3300). It does not show which is the predominant family either in the number of species or in the quantity of individuals as compared with other families; it merely tells how many of the species of one and the same family are indigenous in each country or each quarter of the world. The results of this method are on the whole more exact, because they are obtained by the careful study of single families without the necessity of being acquainted with the whole number of the phanerogamæ belonging to each country. The most varied forms of Ferns, for example, are found between the tropics; it is there, in the tempered heat of moist and shaded places in mountainous islands, that each genus presents the largest number of species: this variety of species in each genus diminishes in passing from the tropical to the temperate zone, and decreases still farther in approaching nearer to the pole. Nevertheless, as in the cold zone—in Lapland, for example—those plants succeed best which can best resist the cold, so the species of Ferns, although the *absolute number* is less than in France or Germany, are yet *relatively* more numerous than in those countries; *i. e.* their number bears a greater proportion to the sum total of all the phanerogamous plants of the country. These proportions or ratios, given as above-mentioned by quotients, are in France and Germany $\frac{1}{73}$ and $\frac{1}{71}$, and in Lapland $\frac{1}{25}$. I published numerical ratios of this kind,—(*i. e.* the entire quantity of phænogamous plants in each of the different Floras divided by the number of species in each family)—in my Prolegomenis de distributione geographica Plantarum, in 1817; and in the Memoir on the distribution of plants over the Earth's surface, subsequently published in the French language, I corrected my previously published numbers by Robert Brown's great works. In advancing from the Equator to the Poles, the ratios taken in this manner vary considerably from the numbers which would be obtained from a comparison of the *absolute* number of species belonging to each family. We often find the value of the fraction increase by the decrease of the denominator, while yet the absolute number of species has diminished. In the method by fractions, which I have followed as more instructive in reference to the geography of plants, there are two variables; for in proceeding from one isothermal line, or one zone of equal temperature, to another, we do not see the sum total of all the phanerogamæ change in the same proportion as does the number of species belonging to a particular family.

We may, if we please, pass from the consideration of species to that of divisions formed in the natural system of botany according to an ideal series of abstractions, and direct our attention to Genera, to Families, and even to the still higher, *i. e.* more comprehensive, Classes. There are some genera, and even some entire families, which belong exclusively to particular zones of the Earth's surface; and this not only because they can only flourish under a particular combination of climatic conditions, but also because both the localities in which they originated, and their migrations, have been limited. It is otherwise with the greater number of genera and of families, which have their representatives in all regions of the globe, and at all latitudes of elevation. The earliest investigations into the distribution of vegetable forms related solely to genera; we find them in a valuable work of Treviranus, in his Biology (Bd. ii. S. 47, 63, 83, and 129). This method is, however, less fitted to afford general results than that which compares either the number of species of each family, or the great leading divisions (of Acotyledons, Monocotyledons, and Dicotyledons) with the sum of all the phanerogamæ. We find that in the cold zones the variety of forms does not decrease so much if estimated by genera as if estimated by species; in other words, we find relatively more genera and fewer species. (Decandolle, Théorie élémentaire de la Botanique, p. 190; Humboldt, Nova genera et species Plantarum, T. i. pp. xvii. and l.) It is almost the same in the case of high mountains whose summits support single members of a large number of genera, which we should have been *à priori* inclined to regard as belonging exclusively to the vegetation of the plains.

I have thought it desirable to indicate the different points of view from which the laws of the geographical distribution of plants may be considered. It is by confounding these different points of view that apparent contradictions are found, which are unjustly attributed to uncertainties of observation. (Jahrbücher der Gewächskunde, Bd. i. Berlin, 1818, S. 18, 21, 30.) When such expressions as the following are made use of—“This form, or this family, diminishes as the cold zones are approached;—it has its true home in such or such a latitude;—it is a southern form;—it predominates in the temperate zone;" care should always be taken to state expressly whether the writer is speaking of the absolute number of species, and its increase or decrease with the change of latitude; or whether he means that the family in question prevails over other families of plants as compared with the entire number of phanerogamæ of which a Flora consists. The impression of prevalence as conveyed by the eye depends on relative quantity.

Terrestrial physics have their numerical elements, as has the System of the Universe, or Celestial Physics, and by the united labours of botanical travellers we may expect to arrive gradually at a true knowledge of the laws which determine the geographical and climatic distribution of vegetable forms. I have already remarked that in the temperate zone the Compositæ (Synanthereæ), and the Glumaceæ (including under this latter name the three families of Grasses, Cyperoidæ and Juncaceæ), make up the fourth part of all phænogamous plants. The following numerical ratios are the results of my investigations for 7 great families of the vegetable kingdom in the same temperate zone.

Glumaceæ	$\frac{1}{8}$ (Grasses alone $\frac{1}{12}$)
Compositæ	$\frac{1}{8}$
Leguminosæ	$\frac{1}{18}$
Labiatæ	$\frac{1}{24}$
Umbelliferæ	$\frac{1}{40}$
Amentaceæ (Cupuliferæ, Betulineæ, and Salicineæ)	$\frac{1}{45}$
Cruciferæ	$\frac{1}{19}$

The forms of organic beings are in reciprocal dependence on each other. In the unity of nature these forms limit each other according to laws which are probably attached to periods of long duration. If on any particular part of the globe we know with accuracy the number of species of one of the great families of Glumaceæ, Leguminosæ, or Compositæ, we may with a tolerable degree of probability form approximative inferences, both as to the sum of all the phanerogamæ of the country, and also as to the number of species belonging to the rest of the leading families of plants. The number of Cyperoidæ determines that of Compositæ, and the number of Compositæ that of Leguminosæ; they even enable us to judge in what classes or orders the Floras of countries are still incomplete, and teach us, if we are on our guard against confounding together very different systems of vegetation, what harvest may still remain to be reaped in the several families.

The comparison of the numerical ratios of families in different already well explored zones, has conducted me to the recognition of laws according to which, in proceeding from the equator to the poles, the vegetable forms constituting a natural family decrease or increase as compared with the whole mass of phanerogamæ belonging to each zone. We have here to regard not only the direction of the change (whether an increase or a decrease), but also its rapidity or measure. We see the denominator of the fraction which expresses the ratio increase or decrease: let us take as our example the beautiful family of Leguminosæ, which decreases in going from the equinoctial zone towards the North Pole. If we find its proportion or ratio for the torrid zone (from 0° to 10° of latitude) at $\frac{1}{10}$, we obtain for the part of the temperate zone which is between 45° and 52° latitude $\frac{1}{18}$, and for the frigid zone (lat. 67° to 70°) only $\frac{1}{35}$. The direction followed by the great family of Leguminosæ (increase on approaching the equator), is also that of the Rubiaceæ, the Euphorbiaceæ, and especially the Malvaceæ. On the contrary, the Grasses and Juncaceæ (the latter still more than the former), diminish in approaching the equator, as do also the Ericeæ and Amentaceæ. The Compositæ, Labiatæ, Umbelliferæ, and Cruciferæ, decrease in proceeding from the temperate zone, either towards the pole or towards the equator, the Umbelliferæ and Cruciferæ decreasing most rapidly in the last-named direction; while at the same time in the temperate zone the Cruciferæ are three times more numerous in Europe than in the United States of North America. On reaching Greenland the Labiatæ have entirely disappeared with the exception of one, and the Umbelliferæ with the exception of two species; the entire number of phænogamous species, still amounting, according to Hornemann, to 315 species.

It must be remarked at the same time that the development of plants of different families, and the distribution of vegetable forms, does not depend exclusively on geographical, or even on isothermal latitude; the quotients are not always on the same isothermal line in the temperate zone, for example, in the plains of North America and those of the Old Continent. Within the tropics there is a very sensible difference between America, India, and the West Coast of Africa. The distribution of organic beings over the surface of the earth does not depend wholly on thermic or climatic relations, which are of themselves very complicated, but also on geological causes almost unknown to us, belonging to the original state of the earth, and to catastrophes which have not affected all parts of our planet simultaneously. The large pachydermatous animals are at the present time wanting in the New Continent, while we still find them in analogous climates in Asia and Africa. These differences ought not to deter us from endeavouring to search out the concealed laws of nature, but should rather stimulate us to the study of them through all their intricacies.

The numerical laws of the families of plants, the often striking agreement of the numbers expressing their ratios, where yet the species of which the families consist are for the most part different, conduct us into the mysterious obscurity which envelopes all that is connected with the fixing of organic types in the species of plants and animals, or with their original formation or creation. I will take as examples two adjoining countries which have both been thoroughly explored—France and Germany. In France, many species of Grasses, Umbelliferæ and Cruciferæ, Compositæ, Leguminosæ, and Labiatæ, are wanting which are common in Germany; and yet the numerical ratios of these six great families are almost identical in the two countries, as will be seen by the subjoined comparison.

Families.	Germany.	France.
Gramineæ.	$\frac{1}{13}$	$\frac{1}{13}$
Umbelliferæ.	$\frac{1}{23}$	$\frac{1}{21}$
Cruciferæ.	$\frac{1}{18}$	$\frac{1}{19}$
Compositæ.	$\frac{1}{8}$	$\frac{1}{7}$
Leguminosæ.	$\frac{1}{18}$	$\frac{1}{16}$
Labiatæ.	$\frac{1}{26}$	$\frac{1}{24}$

This agreement in the number of species in each family compared to the whole number of phænogamous species in the Floras of France and Germany, would not by any means exist if the German species which are missing in France were not replaced there by other types belonging to the same families. Those who are fond of imagining gradual transformations of species, and suppose the different kinds of parrots proper to two islands not far removed from each other to present examples of such a change, will be inclined to attribute the remarkable similarity between the two columns of figures which have just been given, to a migration of species, which, having been the same at first, have been altered gradually by the long-continued action of climatic causes during thousands of years, so that their identity being lost they appear to replace each other. But why is it that our common heather (Calluna vulgaris), why is it that our oaks have never advanced to the eastward of the Ural Mountains, and so passed from Europe to Northern Asia? Why is there no species of the genus Rosa in the Southern Hemisphere, and why are there scarcely any Calceolarias in the Northern Hemisphere? The necessary conditions of temperature are insufficient to explain this. Thermic relations alone cannot, any more than the hypothesis of migrations of plants radiating from certain central points, explain the present distribution of fixed organic forms. Thermic relations are hardly sufficient to explain the limits beyond which individual species do not pass, either in latitude towards the pole at the level of the sea, or in vertical elevation towards the summits of mountains. The cycle of vegetation in each species, however different its duration may be, requires, in order to be successfully passed through, a certain minimum of temperature. (Playfair, in the Transactions of the Royal Society of Edinburgh, vol. v. 1805, p. 202; Humboldt, on the sum of the degrees of temperature required for the cycle of vegetation in the Cerealia, in Mem. sur les lignes isothermes, p. 96; Boussingault, Economie rurale, T. ii. p. 659, 663, and 667; Alphonse Decandolle sur les causes qui limitent les espèces végétales, 1847, p. 8.) But all the conditions necessary for the existence of a plant, either as diffused naturally or by cultivation,—conditions of latitude or minimum distance from the pole, and of elevation or maximum height above the level of the sea, —are farther complicated by the difficulty of determining the commencement of the thermic cycle of vegetation, and by the influence which the unequal distribution of the same quantity of heat into groups of successive days and nights exercises on the excitability, the progressive development, and the whole vital process; to all this must be farther added hygrometric influences and those of atmospheric electricity.

My investigations respecting the numerical laws of the distribution of forms may possibly be applied at some future day with advantage to the different classes of Rotiferæ in the animal creation. The rich collections at the Museum d'Histoire Naturelle in the Jardin des Plantes at Paris, already contained, in 1820, (according to approximate estimations) above 56000 phænogamous and cryptogamous plants in herbariums, 44000 insects (a number doubtless too small, though given me by Latreille), 2500 species of fish, 700 reptiles, 4000 birds, and 500 mammalia. Europe has about 80 species of indigenous mammalia, 400 birds, and 30 reptiles. In the Northern temperate zone, therefore, the species of birds are five times more numerous than those of mammalia, as there are in Europe five times as many Compositæ as there are Amentaceæ and Coniferæ, and five times as many Leguminosæ as there are Orchideæ and Euphorbiaceæ. In the southern hemisphere the ratio of mammalia is in tolerably striking agreement, being as 1 to 4·3. Birds, and still more reptiles, increase in the number of species in approaching the torrid zone more than the mammalia. Cuvier's researches might lead us to believe that the proportion was different in the earlier state of things, and that many more mammalia had perished by revolutions of Nature than birds. Latreille has shewn what groups of insects increase towards the pole, and what towards the equator. Illiger has given the countries of 3800 species of birds according to the quarters of the globe: it would have been much more instructive if the same thing had been done according to zones. We should find little difficulty in comprehending how on a given space of the earth's surface the individuals of a class of plants or animals limit each other's numbers, or how, after long continued contest and many fluctuations caused by the requirements of nourishment and mode of life, a state of equilibrium should be at last established; but the causes which have limited not the number of individuals of a form, but the forms themselves, in a particular space, and founded their typical diversity, are placed beneath the impenetrable veil which still conceals from our eyes all that relates to the manner of the first creation and commencement of organic beings.

If, then, we would attempt to solve the question spoken of in the early part of this dissertation, by giving in an approximate manner the numerical limit, (le nombre limite of French mathematicians), which the whole phanerogamæ now existing on the surface of the earth cannot be supposed to fall short of, we may perhaps find our safest guide in a comparison of the numerical ratios (which, as we have seen, may be assumed to exist between the different families of plants), with the number of species contained in herbariums and cultivated in our great botanic gardens. I have said that in 1820 the number of species contained in the herbariums of the Jardin des Plantes at Paris was already estimated at 56000. I do not permit myself to conjecture the amount which the herbariums of England may contain; but the great Paris herbarium, which was formed with much personal sacrifice by Benjamin Delessert, and given by him for free and general use, was stated at his death to contain 86000 species; a number almost equal to that which, as late as 1835, was conjecturally assigned by Lindley as that of all the species existing on the whole earth. (Lindley, Introduction to Botany, 2d edit. p. 504.) Few herbariums have been reckoned with care, after a complete and strict separation and withdrawal of all mere varieties. Not a few plants contained in smaller collections are still wanting in the greater herbariums which are supposed to be general or complete. Dr. Klotzsch estimates the present entire number of phænogamous plants in the great

Royal Herbarium at Schöneberg, near Berlin, of which he is the curator, at 74000 species.

Loudon's useful work, Hortus Britannicus, gives an approximate view of all the species which are, or at no remote time have been, cultivated in British gardens: the edition of 1832 enumerates, including indigenous plants, exactly 26660 phænogamous species. We must not confound with this large number of plants which have grown or been cultivated at any time and in any part of the whole British Islands, the number of living plants which can be shewn at any single moment of time in any single botanic garden. In this last-named respect the Botanic Garden of Berlin has long been regarded as one of the richest in Europe. The fame of its extraordinary riches rested formerly only on uncertain and approximate estimations, and, as my fellow-labourer and friend of many years' standing, Professor Kunth, has justly remarked (in manuscript notices communicated to the Gartenbau-Verein in December 1846), "no real enumeration or computation could be made until a systematic catalogue, based on a rigorous examination of species, had been prepared. Such an enumeration has given rather above 14060 species: if we deduct from this number 375 cultivated Ferns, we have remaining 13685 phænogamous species; among which we find 1600 Compositæ, 1150 Leguminosæ, 428 Labiatæ, 370 Umbelliferæ, 460 Orchideæ, 60 Palms, and 600 Grasses and Cyperaceæ. If we compare with these numbers those of the species already described in recent works,—Compositæ (Decandolle and Walpers) about 10000; Leguminosæ, 8070; Labiatæ

(Bentham), 2190; Umbelliferæ, 1620; Grasses, 3544; and Cyperaceæ (Kunth, Enumeratio Plantarum), 2000;—we shall perceive that the Berlin Botanic Garden cultivates, of the very large families (Compositæ, Leguminosæ, and Grasses), only 1-7th, 1-8th, and 1-9th;—and of the small families (Labiatæ and Umbelliferæ), about 1-5th, or 1-4th, of described species. If, then, we estimate the number of all the different phænogamous plants cultivated at one time in all the botanic gardens of Europe at 20000, we find that the cultivated species appear to be about the eighth part of those which are already either described or preserved in herbariums, and that these must nearly amount to 160000. This estimate need not be thought excessive, since of many of the larger families, (for example, Guttiferæ, Malpighiaceæ, Melastomeæ, Myrtaceæ, and Rubiaceæ), hardly a hundredth part are found in our garden." If we take the number given by Loudon in his Hortus Britannicus (26660 species) as a basis, we shall find, (according to the justly drawn succession of inferences of Professor Kunth, in the manuscript notices from which I have borrowed the above), the estimate of 160000 species rise to 213000; and even this is still very moderate, for Heynhold's Nomenclator botanicus hortensis (1846) even rates the phænogamous species then cultivated at 35600; whereas I have employed Loudon's number for 1832, viz. 26660. On the whole it would appear from what has been said,—and the conclusion is at first sight a sufficiently striking one,—that at present there are almost more known species of phænogamous plants (with which we are acquainted by gardens, descriptions, or herbariums), than there are known insects. According to the average of the statements which I have received from several of our most distinguished entomologists whom I have had the opportunity of consulting, the number of insects at present described, or contained in collections without being described, may be taken at between 150000 and 170000 species. The rich Berlin collection does not contain less than 90000 species, among which are about 32000 Coleoptera. A very large number of plants have been collected in distant parts of the globe, without the insects which live on them or near them being brought at the same time. If, however, we limit the estimates of numbers to a single part of the world, and that the one which has been the best explored in respect to both plants and insects, viz. Europe, we find a very different proportion; for while we can hardly enumerate between seven and eight thousand European phænogamous plants, more than three times that number of European insects are already known. According to the interesting communications of my friend Dohrn at Stettin, 8700 insects have already been collected from the rich Fauna of that vicinity, (and many micro-Lepidopteræ are still wanting), while the phænogamous plants of the same district scarcely exceed 1000. The Insect Fauna of Great Britain is estimated at 11600 species. Such a preponderance of animal forms need the less surprise us, since large classes of insects subsist solely on animal substances, and others on agamous vegetation (funguses, and even those which are subterranean). Bombyx pini alone (the spider which infests the Scotch fir, and is the most destructive of all forest insects), is visited, according to Ratzeburg, by thirty-five parasitical Ichneumonides.

If these considerations have led us to the proportion borne by the species of plants cultivated in gardens to the entire amount of those which are already either described or preserved in herbariums, we have still to consider the proportion borne by the latter to what we conjecture to be the whole number of forms existing upon the earth at the present time; *i. e.* to test the assumed minimum of such forms by the relative numbers of species in the different families, therefore, by uncertain multipliers. Such a test, however, gives for the lowest limit or minimum number results so low as to lead us to perceive that even in the great families,—our knowledge of which has been of late most strikingly enriched by the descriptions of botanists,—we are still acquainted with only a small part of existing plants. The Repertorium of Walpers completes Decandolle's Prodromus of 1825, up to 1846: we find in it, in the family of Leguminosæ, 8068 species. We may assume the ratio, or relative numerical proportion of this family to all phænogamous plants, to be $\frac{1}{21}$—as we find it $\frac{1}{10}$ within the tropics, $\frac{1}{18}$ in the middle temperate, and $\frac{1}{33}$ in the cold northern zone. The *described* Leguminosæ would thus lead us to assume only 169400 existing phænogamous species on the whole surface of the earth, whereas, as we have shewn, the Compositæ indicate more than 160000 already *known* species. The discordance is instructive, and may be further elucidated and illustrated by the following analogous considerations.

The major part of the Compositæ, of which Linnæus knew only 785 species and which has now grown to 12000, appear to belong to the Old Continent: at least Decandolle described only 3590 American, whilst the European, Asiatic, and African species amounted to 5093. This apparent richness in Compositæ is, however, illusive, and considerable only in appearance; the ratio or quotient of the family, ($\frac{1}{15}$ between the tropics, $\frac{1}{7}$ in the temperate zone, and $\frac{1}{13}$ in the cold zone), shews that even more species of Compositæ than Leguminosæ must hitherto have escaped the researches of travellers; for a multiplication by 12 would give us only the improbably low number of 144000 Phænogamous species. The families of Grasses and Cyperaceæ give still lower results, because comparatively still fewer of their species have been described and collected. We have only to cast our eyes on the map of South America, remembering the wide extent of territory occupied by grassy plains, not only in Venezuela and on the banks of the Apure and the Meta, but also to the south of the forest-covered regions of the Amazons, in Chaco, Eastern Tucuman, and the Pampas of Buenos Ayres and Patagonia, bearing in mind that of all these extensive regions the greater part have never been explored by botanists, and the remainder only imperfectly and incompletely so. Northern and Central Asia offer an almost equal extent of Steppes, but in which, however, dicotyledonous herbaceous plants are more largely mingled with the Gramineæ. If we had sufficient grounds for believing that we are now acquainted with half the phænogamous plants on the globe, and if we took the number of known species only at one or other of the before-mentioned numbers of 160000 or 213000, we should still have to take the number of grasses (the general proportion of which appears to be $\frac{1}{12}$), in the first case at least at 26000, and in the second case at 35000 different species, which would give respectively in the two cases only either $\frac{1}{8}$ or $\frac{1}{10}$ part as known.

The assumption that we already know half the existing species of phænogamous plants is farther opposed by the following considerations. Several thousand species of Monocotyledons and Dycotyledons, and among them tall trees,—(I refer here to my own Expedition),—have been discovered in regions, considerable portions of which had been previously examined by distinguished botanists. The portions of the great continents which have never even been trodden by botanical observers considerably exceed in area those which have been traversed by such travellers, even in a superficial manner. The greatest variety of phænogamous vegetation, *i. e.* the greatest number of species on a given area, is found between the tropics, and in the sub-tropical zones. This last-mentioned consideration renders it so much the more important to remember how almost entirely unacquainted we are, on the New Continent, north of the equator, with the Floras of Oaxaca, Yucatan, Guatimala, Nicaragua, the Isthmus of Panama, Choco, Antioquia, and the Provincia de los Pastos; —and south of the equator, with the Floras of the vast forest region between the Ucayale, the Rio de la Madera, and the Tocantin (three great tributaries of the Amazons), and with those of Paraguay and the Provincia de los Misiones. In Africa, except in respect to the coasts, we know nothing of the vegetation from 15° north to 20° south latitude; in Asia we are unacquainted with the Floras of the south and south-east of Arabia, where the highlands rise to about 6400 English feet above the level of the sea,—of the countries between the Thian-schan, the Kuenlün, and the Himalaya, all the west part of China, and the greater part of the countries beyond the Ganges. Still more unknown to the botanist are the interior of Borneo, New Guinea, and part of Australia. Farther to the south the number of species undergoes a wonderful diminution, as Joseph Hooker has well and ably shewn from his own observation in his Antarctic Flora. The three islands of which New Zealand consists extend from $34\frac{1}{2}°$ to $47\frac{1}{4}°$ S. latitude, and as they contain, moreover, snowy mountains of above 8850 English feet elevation, they must include considerable diversity of climate. The Northern Island has been examined with tolerable completeness from the voyage of Banks and Solander to Lesson and the Brothers Cunningham and Colenso, and yet in more than 70 years we have only become acquainted with less than 700 phænogamous species. (Dieffenbach, Travels in New Zealand, 1843, vol. i. p. 419.) The paucity of vegetable corresponds to the paucity of animal species. Joseph Hooker, in his Flora Antarctica, p. 73-75, remarks that "the botany of the densely wooded regions of the Southern Islands of the New Zealand group and of Fuegia is much more meagre not only than that of similarly clothed regions of Europe, but of islands many degrees nearer to the Northern pole than these are to the Southern one. Iceland, for instance, which is from 8 to 10 degrees farther from the equator than the Auckland and the Campbell Islands, contains certainly five times as many flowering plants. In the Antarctic Flora, under the influence of a cool and moist, but singularly equable climate, great uniformity, arising from paucity of species, is associated with great luxuriance of vegetation. This striking uniformity prevails both at different levels, (the species found on the plains appearing also on the slopes of the mountains), and over vast extents of country, from the south of Chili to Patagonia, and even to Tierra del Fuego, or from lat. 45° to 56°. Compare, on the other hand, in the northern temperate region, the Flora of the South of France, in the latitude of the Chonos Archipelago on the coast of Chili, with the Flora of Argyleshire in Scotland in the latitude of Cape Horn, and how great a difference of species is found; while in the Southern Hemisphere the same types of vegetation pass through many degrees of latitude. Lastly, on Walden Island, in lat. 80½° N., or not ten degrees from the North Pole of the earth, ten species of flowering plants have been collected, while in the southernmost islet of the South Shetlands, though only in lat. 63° S., only a solitary grass was found." These considerations on the distribution of plants confirm the belief that the great mass of still unobserved, uncollected, and undescribed flowering plants must be sought for in tropical countries, and in the latitudes from 12° to 15° distant from the tropics.

It has appeared to me not unimportant to show the imperfect state of our knowledge in this still little cultivated department of arithmetical botany, and to propound numerical questions in a more distinct and determinate manner than could have been previously done. In all conjectures respecting numerical relations we must seek first for the possibility of deducing the lower or minimum limits; as in a question treated of by me elsewhere, on the proportion of coined gold and silver to the quantity of the precious metal fabricated in other ways; or as in the questions of how many stars, from the 10th to the 12th magnitude, are dispersed over the sky, and how many of the smallest telescopic stars the Milky Way may contain. (John Herschel, Results of Astron. Observ. at the Cape of Good Hope, 1847, p. 381.) We may consider it as established, that if it were possible to know completely and thoroughly by observation all the species belonging to *one* of the great families of phanerogamous or flowering plants, we should learn thereby at the same time, approximatively, the entire sum of *all* such plants (including all the families). As, therefore, by the progressive exploration of new countries we progressively and gradually exhaust the remaining unknown species of any of the great families, the previously assigned lowest limit rises gradually higher, and since the forms reciprocally limit each other in conformity with still undiscovered laws of universal organisation, we approach continually nearer to the solution of the great numerical problem of organic life. But is the number of organic forms itself a constant number? Do new vegetable forms spring from the ground after long periods of time, while others become more and more rare, and at last disappear? Geology, by means of her historical monuments of ancient terrestrial life, answers to the latter portion of this question affirmatively. "In the Ancient World," to use the remark of an eminent naturalist, Link (Abhandl. der Akad. der Wiss. zu Berlin aus dem Jahr 1846, S. 322), "we see characters, now apparently remote and widely separated from each other, associated or crowded together in wondrous forms, as if a greater development and separation awaited a later age in the history of our planet."

(14) p. 19.—"*If the height of the aerial ocean and its pressure have not always been the same.*"

The pressure of the atmosphere has a decided influence on the form and life of plants. From the abundance and importance of their leafy organs provided with porous openings, plants live principally in and through their surfaces; and hence their dependence on the surrounding medium. Animals are dependent rather on internal impulses and stimuli; they originate and maintain their own temperature, and, by means of muscular movement, their own electric currents, and the chemical vital processes which depend on and react upon those currents. A species of skin-respiration is an active and important vital function in plants, and this respiration, in so far as it consists in evaporation, inhalation, and exhalation of fluids, is dependent on the pressure of the atmosphere. Therefore it is that alpine plants are more aromatic, and are hairy and covered with numerous pores. (See my work über die gereizte Muskel-und Nervenfaser, Bd. ii. S. 142-145.) For according to Zoonomic experience, organs become more abundant and more perfect in proportion to the facility with which the conditions necessary for the exercise of their functions are fulfilled,—as I have elsewhere shown. In alpine plants the disturbance of their skin-respiration occasioned by increased atmospheric pressure makes it very difficult for such plants to flourish in the low grounds.

The question whether the mean pressure of the aerial ocean which surrounds our globe has always been the same is quite undecided: we do not even know accurately whether the mean height of the barometer has continued the same at the same place for a century past. According to Poleni's and Toaldo's observations, the pressure would have seemed to vary. The correctness of these observations has long been doubted, but the recent researches of Carlini render it almost probable that the mean height of the barometer is diminishing in Milan. Perhaps the phenomenon is a very local one, and dependent on variations in descending atmospheric currents.

(15) p. 20.—" *Palms.*"

It is remarkable that of this majestic form of plants,—(some of which rise to more than twice the height of the Royal Palace at Berlin, and to which the Indian

Amarasinha gave the characteristic appellation of "Kings among the Grasses"),—up to the time of the death of Linnæus only 15 species were described. The Peruvian travellers Ruiz and Pavon added to these 8 more species. Bonpland and I, in passing over a more extensive range of country from 12° S. lat. to 21° N. lat., described 20 new species of palms, and distinguished as many more, but without being able to obtain complete specimens of their flowers. (Humboldt de distrib. geogr. Plantarum, p. 225—233.) At the present time, 44 years after my return from Mexico, there are from the Old and New World, including the East Indian species brought by Griffith, above 440 regularly described species. The Enumeratio Plantarum of my friend Kunth, published in 1841, had already 356 species.

A few, but only a few species of palms, are, like our Coniferæ, Quercineæ, and Betulineæ, social plants: such are the Mauritia flexuosa, and two species of Chamærops, one of which, the Chamærops humilis, occupies extensive tracts of ground near the Mouth of the Ebro and in Valencia; and the other, C. mocini, discovered by us on the Mexican shore of the Pacific and entirely without prickles, is also a social plant. While some kinds of palms, including Chæmerops and Cocos, are littoral or shore-loving trees, there is in the tropics a peculiar group of mountain palms, which if I am not mistaken was entirely unknown previous to my South American travels. Almost all species of the family of palms grow on the plains or low grounds in a mean temperature of between 22° and 24° Reaumur

(81°.5 and 86°, Fahr.); rarely ascending so high as 1900 English feet on the declivities of the Andes: but in the mountain palms to which I have alluded, the beautiful Wax-palm (Ceroxylon andicola), the Palmeto of Azufral at the Pass of Quindiu (Oreodoxa frigida), and the reed-like Kunthia montana (Caña de la Vibora) of Pasto, attain elevations between 6400 and 9600 English feet above the level of the sea, where the thermometer often sinks at night as low as 4°.8 and 6° of Reaumur (42°.8 and 45.°5, Fahr.), and the mean temperature scarcely amounts to 11° Reaumur, or 56°.8 Fahrenheit. These Alpine Palms grow among Nut trees, yew-leaved species of Podocarpus and Oaks (Quercus granatensis). I have determined by exact barometrical measurement the upper and lower limits of the range of the Wax-Palm. We first began to find it on the eastern declivity of Andes of Quindiu, at the height of 7440 (about 7930 English) feet above the level of the sea, and it extended upwards as far as the Garita del Paramo and los Volcancitos, or to 9100 (almost 9700 English) feet: several years after my departure from the country the distinguished botanist Don Jose Caldas, who had been long our companion amidst the mountains of New Granada, and who afterwards fell a victim to Spanish party hatred, found three species of palms growing in the Paramo de Guanacos very near the limits of perpetual snow; therefore probably at an elevation of more than 13000 (13855 English) feet. (Semanario de Santa Fé de Bogotá, 1809, No. 21, p. 163.) Even beyond the tropics, in the latitude of 28° North, the Chamærops martiana reaches on the sub-Himalayan mountains a height of 5000 English feet. (Wallich, Plantæ Asiaticæ, Vol. iii. Tab. 211.)

If we look for the extreme geographical limits of palms, (which are also the extreme climatic limits in all the species which inhabit localities but little raised above the level of the sea), we see some, as the date-palm, the Chamærops humilis, C. palmetto, and the Areca sapida of New Zealand, advance far into the temperate zones of either hemisphere, into regions where the mean temperature of the year hardly equals 11°.2 and 12°.5 Reaumur (57°.2, and 60°.2 Fahrenheit). If we form a series of cultivated plants or trees, placed in order of succession according to the degree of heat they require, and beginning with the maximum, we have Cacao, Indigo, Plantains, Coffee, Cotton, Date-palms, Orange and Lemon Trees, Olives, Sweet Chestnuts, and Vines. In Europe, date-palms (introduced, not indigenous) grow mingled with Chamærops humilis in the parallels of 43½° and 44°, as on the Genoese Rivera del Ponente, near Bordighera, between Monaco and San Stefano, where there is an assemblage of more than 4000 palm-stems; and in Dalmatia round Spalatro. It is remarkable that Chamærops humilis is abundant both at Nice and in Sardinia, and yet is not found in the island of Corsica which lies between those localities. In the New Continent, the Chamærops palmetto, which is sometimes above 40 English feet high, only advances as far North as 34° latitude, a difference sufficiently explained by the inflexions of the isothermal lines. In the Southern hemisphere, in New Holland, palms, of which there are very few, (six or seven species) only advance to 34° of latitude (see Robert Brown's general remarks on the Botany of Terra Australis, p. 45) ; and in New Zealand, where Sir Joseph Banks first saw an Areca palm, they reach the 38th parallel. In Africa, which, quite contrary to the ancient and still widely prevailing belief, is poor in species of palms, only one palm, the Hyphæne coriacea, advances to Port Natal in 30° latitude. The continent of South America presents almost the same limits in respect to latitude. On the eastern side of the Andes, in the Pampas of Buenos Ayres and in the Cis-Plata province, palms extend, according to Auguste de St.-Hilaire, to 34° and 35° S. latitude. This is also the latitude to which on the western side of the Andes the Coco de Chile (our Jubæa spectabilis?), the only Chilian palm, extends, according to Claude Gay, being as far as the banks of the Rio Maule. (See also Darwin's Journal, edition of 1845, p. 244 and 256).

I will here introduce some detached remarks which I wrote in March, 1801, on board the ship in which we were sailing from the palmy shores of the mouth of the Rio Sinu, west of Darien, to Cartagena de las Indias.

"We have now, in the course of the two years which we have spent in South America, seen 27 different species of palms. How many must Commerson, Thunberg, Banks, Solander, the two Forsters, Adanson, and Sonnerat, have observed in their distant voyages! Yet, at the present moment, when I write these lines, our systems of botany do not include more than from 14 to 18 systematically described species. In truth, the difficulty of procuring the flowers of palms is greater than can readily be imagined. We have felt it so much the more from having especially directed our attention to Palms, Grasses, Cyperaceæ, Junceæ, Cryptogamous Plants, and such other objects as have been least studied hitherto. Most species of palms flower only once a year, in the neighbourhood of the Equator in the months of January and February. But how often is it impossible for travellers to be precisely at that season in places where palms are principally found. In many species of palms the flowers last only so few days that one almost always arrives too late, and finds the fertilization completed and the male blossoms gone. Frequently only three or four species of palms are found in areas of 2000 square German geographical miles (3200 English geographical square miles). How is it possible during the short flowering season to visit the different places where palms abound: the Missions on the Rio Caroni, the Morichales at the mouth of the Orinoco, the valley of Caura and Erevato, the banks of the Atabapo and the Rio Negro, and the side of the Duida Mountain? Add to this the difficulty of reaching the flowers, when, in the dense forests, or on the swampy river banks, (as on the Temi and Tuamini), one sees them hanging from stems above 60 feet high, and armed with formidable spines. A traveller, when preparing to leave Europe on an expedition in which natural history is one of his leading objects, flatters himself with the thoughts of shears or curved blades fastened to long poles, with which he imagines he will be able to reach and cut down whatever he desires; he dreams, too, of native boys, who, with a cord fastened to their two feet, are to climb up the highest trees at his bidding. But, alas! very few of these fancies are ever realised; the great height of the blossoms renders the poles useless; and in the missions established on the banks of the rivers of Guiana, the traveller finds himself among Indians whose poverty, stoicism, and uncultivated state, renders them so rich, and so free from wants of every kind, that neither money nor other presents that can be made to them will induce them to turn three steps out of their path. This insurmountable apathy is the more provoking to a European, because he sees the same people climb with inconceivable agility wherever their own fancies lead them; for example, when they wish to catch a parrot, or an iguana, or a monkey, which having been wounded by their arrows saves himself from falling by holding on to the branches with his prehensile tail. Even at the Havannah we met with a similar disappointment. We were there in the month of January, and saw all the trees of the Palma Real (our Oreodoxa Regia), in the immediate vicinity of the city and on the public walks, adorned with snow-white blossoms. For several days we offered the negro boys whom we met in the streets of Regla and Guanavacoa two piastres for a single bunch of the blossoms which we wanted, but in vain! Between the tropics men are indisposed to laborious exertion, unless compelled by constraint or by extreme destitution. The botanists and artists of the Royal Spanish Commission for researches in Natural History, under the direction of Count Jaruco y Mopor (Estevez, Boldo, Guio, and Echeveria),—acknowledged to us that during several years they had not been able to obtain these flowers for examination. These difficulties sufficiently explain what would have been incomprehensible to me before my voyage, namely, that although during our two years' stay up to the present time, we have, indeed, discovered more than 20 different species of palms, we have as yet been only able to describe systematically 12. "How interesting a work might be produced by a traveller in South America who should occupy himself exclusively with the study of palms, and should make drawings of the spathe, spadix, inflorescence, and fruit, all of the size of nature!" (I wrote this many years before the Brazilian travels of Martius and Spix, and the admirable and excellent work of Martius on Palms.) "There is considerable uniformity in the shape of the leaves of palms; they are generally either pinnate (feathery, or divided like the plume of a feather);—or else palmate or palmo-digitate (of a fan-like form); the leaf-stalk (petiolus), is in some species without spines, in others sharply toothed (serrato-spinosus). The form of the leaf in Caryota urens and Martinezia caryotifolia, (which we saw on the banks of the Orinoco and Atabapo, and again in the Andes, at the pass of Quindiu, 3000 Fr. (3197 English) feet above the level of the sea), is exceptional and almost unique among palms, as is the form of the leaf of the Gingko among trees. The port and physiognomy of palms have a grandeur of character very difficult to convey by words. The stem, shaft, or caudex, is generally simple and undivided, but in extremely rare exceptions divides into branches in the manner of the Dracænas, as in Cucifera thebaica (the Doum-palm), and Hyphæne coriacea. It is sometimes disproportionately thick (as in Corozo del Sinu, our Alfonsia oleifera); sometimes feeble as a reed (as in Piritu, Kunthia montana, and the Mexican Corypha nana); sometimes swelling towards the base (as in Cocos); sometimes smooth, and sometimes scaly (Palma de covija o de sombrero, in the Llanos); sometimes armed with spines (as Corozo de Cumana and Macanilla de Caripe), the long spines being distributed with much regularity in concentric rings."

"Characteristic differences are also furnished in some species by roots which, springing from the stem at about a foot or a foot and a half above the ground, either raise the stem as it were upon a scaffolding, or surround it with thick buttresses. I have seen Viverras, and even very small monkeys, pass underneath this kind of scaffolding formed by the roots of the Caryota. Often the shaft or stem is swollen only in the middle, being more slender above and below, as in the Palma Real of the Island of Cuba. The leaves are sometimes of a dark and shining green (as in the Mauritia and the Cocoa nut palm); sometimes of a silvery white on the under side (as in the slender Fan-palm, Corypha miraguama, which we found in the Harbour of Trinidad de Cuba). Sometimes the middle of the fan or palmate leaf is ornamented with concentric yellowish or bluish stripes like a peacock's tail; as in the thorny Mauritia which Bonpland discovered on the banks of the Rio Atabapo."

"The direction of the leaves is a character not less important than their form and colour. The leaflets (foliola), are sometimes arranged like the teeth of a comb, set on in the same plane, and close to each other, and having a very rigid parenchyma (as in Cocos, and in Phœnix the genus to which the Date belongs); whence the fine play of light from the sun-beams falling on the upper surface of the leaves (which is of a fresher verdure in Cocos, and of a more dead and ashy hue in the date palm); sometimes the leaves are flag-like, of a thinner and more flexible texture, and curl towards the extremities (as in Jagua, Palma Real del Sinu, Palma Real de Cuba, and Piritu dell' Orinoco). The peculiarly majestic character of palms is given not only by their lofty stems, but also in a very high degree by the direction of their leaves. It is part of the beauty of any particular species of palms that its leaves should possess this aspiring character; and not only in youth, as is the case in the Date-palm, but also throughout the duration of the life of the tree. The more upright the direction of the leaves, or, in other words, the more acute the angles which they form with the upper part or continuation of the stem, the grander and more imposing is the general character and physiognomy of the tree. How different are the character and aspect given by the drooping leaves of the Palma de covija del Orinoco y de los Llanos de Calabozo (Corypha tectorum); the more nearly horizontal or at least less upright leaves of the Date and Cocoa-nut palms; and the aspiring heavenward pointing branches of the Jagua, the Cucurito, and the Pirijao!

Nature has lavished every beauty of form on the Jagua palm, which, intermingled with the Cucurito or Vadgihai, (85 to 106 English feet high), adorns the cataracts of Atures and Maypures, and is occasionally found also on the lonely banks of the Cassiquiare. The smooth slender stems of the Jagua, rising to between 64 and 75 English feet, appear above the dense mass of foliage of other kinds of trees from amidst which they spring like raised colonnades, their airy summits contrasting beautifully with the thickly-leaved species of Ceiba, and with the forest of Laurineæ, Calophyllum, and different species of Amyris which surround them. The leaves of the Jagua, which are few in number (scarcely so many as seven or eight), are sixteen or seventeen feet long, and rise almost vertically into the air; their extremities are curled like plumes; the ultimate divisions or leaflets, having only a thin grass-like parenchyma, flutter lightly and airily round the slowly balancing central leaf-stalks. In all palms the inflorescence springs from the trunk itself, and below the place where the leaves originate; but the manner in which this takes place modifies the physiognomic character. In a few species only (as the Corozo del Sinu), the spathe (or sheath enclosing the flowers and fruits), rises vertically, and the fruits stand erect, forming a kind of thyrsus, like the fruits of the Bromelia: in most species of palms the spathes (which are sometimes smooth and sometimes rough and armed with formidable spines) are pendent; in a few species the male flowers are of a dazzling whiteness, and in such cases the flower-covered spadix, when fully developed, shines from afar. In most species of palms the male flowers are yellowish, closely crowded, and appear almost withered when they disengage themselves from the spathe.

"In Palms with pinnate foliage, the leaf-stalks either proceed (as in the Cocoa-nut, the Date, and the Palma Real del Sinu) from the dry, rough, woody part of the stem; or, as in the Palma Real de la Havana (Oreodoxa regia) seen and admired by Columbus, there rises upon the rough part of the stem a grass-green, smooth, thinner shaft, like a column placed upon a column, and from this the leaf-stalks spring. In fan-palms, "foliis palmatis," the leafy crown (as in the Moriche and the Palma sombrero de la Havana) often rests on a previous bed of dry leaves, a circumstance which gives to the tree a sombre and melancholy appearance. In some umbrella-palms the crown consists of very few leaves, which rise upwards, carried on very slender petioles or foot-stalks (as in Miraguama).

"The form and colour of the fruits of Palms also offer much more variety than is commonly believed in Europe. Mauritia flexuosa bears egg-shaped fruits, whose scaly, brown, and shining surface, gives them something of the appearance of young fir-cones. What a difference between the enormous triangular cocoa-nut, the soft fleshy berries of the date, and the small hard fruits of the Corozo! But among the fruits of palms none equal in beauty those of the Pirijao (Pihiguao of S. Fernando de Atabapo and S. Balthasar); they are egg-shaped, mealy, and usually without seeds, two or three inches thick, and of a golden colour, which on one side is overspread with crimson; and these richly coloured fruits, crowded together in a bunch, like grapes, are pendent from the summits of majestic palm trees." I have already spoken in the first volume of the present work, p. 216, of these beautiful fruits, of which there are seventy or eighty in a bunch, and which can be prepared as food in a variety of ways, like plantains and potatoes.

In some species of Palms the flower sheath, or spathe surrounding the spadix and the flowers, opens suddenly with an audible sound. Richard Schomburgk (Reisen in Britisch Guiana, Th. i. S. 55) has like myself observed this phenomenon in the flowering of the Oreodoxa oleracea. This first opening of the flowers of Palms accompanied by sound recalls the vernal Dithyrambus of Pindar, and the moment when, in Argive Nemea, "the first opening shoot of the date-palm proclaims the arrival of balmy spring." (Kosmos, Bd. ii. S. 10; Eng. ed. p. 10.)

Three vegetable forms of peculiar beauty are proper to the tropical zone in all parts of the globe; Palms, Plantains or Bananas, and Arborescent Ferns. It is where heat and moisture are combined that vegetation is most vigorous, and its forms most varied; and hence South America excels the rest of the tropical world in the number and beauty of her species of Palms. In Asia this form of vegetation is more rare, perhaps because a considerable part of the Indian continent which was situated immediately under the equinoctial line has been broken up and covered by the sea in the course of former geological revolutions. We know scarcely anything of the palm trees of Africa between the Bight of Benin and the Coast of Ajan; and, generally speaking, we are only acquainted, as has been already remarked, with a very small number of species of Palms belonging to that quarter of the globe.

Palms afford, next to Coniferæ and species of Eucalyptus belonging to the family of Myrtaceæ, examples of the greatest loftiness of stature attained by any of the members of the vegetable kingdom. Of the Cabbage Palm (Areca oleracea), stems have been seen from 150 to 160 French (160 to 170 English) feet high. (Aug. de Saint-Hilaire, Morphologie végétale, 1840, p. 176.) The Wax-palm, our Ceroxylon andicola, discovered by us on the Andes between Ibague and Carthago, on the Montaña de Quindiu, attains the immense height of 160 to 180 French (170 to 192 English) feet. I was able to measure with exactness the prostrate trunks which had been cut down and were lying in the forest. Next to the Wax-palm, Oreodoxa Sancona, which we found in flower near Roldanilla in the Cauca Valley, and which affords a very hard and excellent building wood, appeared to me to be the tallest of American palms. The circumstance that notwithstanding the enormous quantity of fruits produced by a single Palm tree, the number of individuals of each species which are found in a wild state is not very considerable, can only be explained by the frequently abortive development of the fruits (and consequent absence of seeds), and by the voracity of their numerous assailants, belonging to all classes of the animal world. Yet although I have said that the wild individuals are not very numerous, there are in the basin of the Orinoco entire tribes of men who live for several months of the year on the fruits

of palms. "In palmetis, Pihiguao consitis, singuli trunci quotannis fere 400 fructus ferunt pomiformes, tritumque est verbum inter Fratres S. Francisci, ad ripas Orinoci et Gauiniæ degentes, mire pinguescere Indorum corpora, quoties uberem Palmæ fructum fundant." (Humboldt, de Distrib. geogr. Plant. p. 240.)

(16) p. 22.—" *Since the earliest infancy of human civilisation.*"

In all tropical countries we find the cultivation of the Banana or Plantain established from the earliest times with which tradition or history make us acquainted. It is certain that in the course of the last few centuries African slaves have brought new varieties to America, but it is equally certain that Plantains were cultivated in the new world before its discovery by Columbus. The Guaikeri Indians at Cumana assured us that on the Coast of Paria, near the Golfo Triste, when the fruits were allowed to remain on the tree till ripe, the plantain sometimes produced seeds which would germinate; and in this manner plantains are occasionally found growing wild in the recesses of the forest, from ripe seeds conveyed thither by birds. Perfectly formed seeds have also sometimes been found in plantain fruits at Bordones, near Cumana. (Compare my Essai sur la Géographie des Plantes, p. 29; and my Relat. hist. T. i. pp. 104 and 587, T. ii. pp. 355 and 367.)

I have already remarked elsewhere (Kosmos, Bd. ii. S. 191; English edition, p. 156), that Onesieritus and the other companions of Alexander, while they make no allusion to the tall arborescent ferns, speak of the fan-leaved umbrella palm, and of the delicate and always fresh verdure of the cultivated plantains or bananas. Among the Sanscrit names given by Amarasinha for the plantain or banana (the Musa of botanists) there are bhanu-phala (sun-fruit), varana-buscha, and moko. Phala signifies fruit in general. Lassen explains the words of Pliny (xii. 6), "arbori nomen palæ, pomo arienæ" thus: "The Roman mistook the word pala, fruit, for the name of the tree; and varana (in the mouth of a Greek ouarana) became transformed into ariena. The Arabic mauza may have been formed from moko, and hence our Musa. Bhanu-fruit is not far from banana-fruit." (Compare Lassen, Indische Alterthumskunde, Bd. i. S. 262, with my Essai politique sur la Nouvelle Espagne, T. ii. p. 382, and Rel. hist. T. i. p. 491.)

(17) p. 22.—" *The form of Malvaceæ.*"

Larger malvaceous forms begin to appear as soon as we have crossed the Alps; at Nice and in Dalmatia, Lavatera arborea; and in Liguria, Lavatera olbia. The dimensions of the Baobab, monkey-bread tree, have been mentioned above, (Vol. ii. p. 90.) To this form are attached the also botanically allied families of the Byttneriaceæ (Sterculia, Hermannia, and the large-leaved Theobroma Cacao, in which the flowers spring from the bark both of the trunk and the roots); the Bombaceæ (Adansonia, Helicteres, and Cheirostemon); and lastly the Tiliaceæ (Sparmannia Africana.) I may name more particularly as superb representatives of the Mallow-form, our Cavanillesia platanifolia, of

Turbaco near Carthagena in South America, and the celebrated Ochroma-like Hand-tree, the Macpalxochiquahuitl of the Mexicans, (from *macpalli,* the flat hand), Arbol de las Manitas of the Spaniards, our Cheirostemon platanoides; in which the long curved anthers project beyond the fine purple blossom, causing it to resemble a hand or claw. Throughout the Mexican States this one highly ancient tree is the only existing individual of this extraordinary race: it is supposed to be a stranger, planted about five centuries ago by the kings of Toluca. I found the height above the sea where the Arbol de las Manitas stands to be 8280 French (8824 English) feet. Why is there only a single individual, and from whence did the kings of Toluca procure either the young tree or the seed? It seems no less difficult to account for Montezuma not having possessed it in his botanical gardens of Huaxtepec, Chapoltepec, and Iztapalapan, of which Hernandez, the surgeon of Philip II., was still able to avail himself, and of which some traces remain even to the present day; and it seems strange that it should not have found a place among the representations of objects of natural history which Nezahualcoyotl, king of Tezcuco, caused to be drawn half a century before the arrival of the Spaniards. It is asserted that the Hand-tree exists in a wild state in the forests of Guatimala. (Humboldt and Bonpland, Plantes équinoxiales, T. i. p. 82, pl. 24; Essai polit. sur la Nouv. Esp., T. i. p. 98.) At the equator we have seen two Malvaceæ, Sida Phyllanthos (Cavan), and Sida pichinchensis, ascend, on the mountain of Antisana and the Volcano Rucu-Pichincha, to the great elevations of 12600 and 14136 French (13430 and 15066 English) feet. (See our Plantes équin., T. ii. p. 113, pl. 116.) Only the Saxifraga boussingaulti (Brongn.) reaches, on the slope of the Chimborazo, an altitude six or seven hundred feet higher.

(18) p. 22.—"*The Mimosa form.*"

The finely feathered or pinnated leaves of Mimosas, Acacias, Schrankias, and species of Desmanthus, are most truly forms of tropical vegetation. Yet there are some representations of this form beyond the tropics; in the northern hemisphere in the Old Continent I can indeed cite but one, and that only in Asia, and a low-growing shrub, the Acacia Stephaniana, according to Kunth's more recent investigations a species of the genus Prosopis. It is a social plant, covering the arid plains of the province of Shirwan, on the Kur (Cyrus), as far as the ancient Araxes. Olivier also found it near Bagdad. It is the Acacia foliis bipinnatis mentioned by Buxbaum, and extends as far north as 42° of latitude. (Tableau des Provinces situées sur la Côte occidentale de la Mer Caspienne, entre les fleuves Terek et Kour, 1798, pp. 58 and 120.) In Africa the Acacia gummifera of Willdenow advances as far as Mogador, or to 32° north latitude.

On the New Continent, the banks of the Mississipi and the Tennessee, as well as the savannahs of Illinois, are adorned with Acacia glandulosa (Michaux), and A. brachyloba (Willd). Michaux found the Schrankia uncinata extend northwards from Florida into Virginia, or to 37° N. latitude. Gleditschia tricanthos is found, according to Barton, on the east side of the Alleghany mountains, as far north as the 38th parallel, and on the west side even as far as the 41st parallel. Gleditschia monosperma ceases two degrees farther to the south. These are the limits of the Mimosa form in the northern hemisphere. In the southern hemisphere we find beyond the tropic of Capricorn simple leaved Acacias as far as Van Diemen Island; and even the Acacia cavenia, described by Claude Gay, grows in Chili between the 30th and 37th degrees of south latitude. (Molina, Storia Naturale del Chili, 1782, p. 174.) Chili has no true Mimosa, but it has three species of Acacia. Even in the north part of Chili the Acacia cavenia only grows to a height of twelve or thirteen feet; and in the south, near the sea coast, it hardly rises a foot above the ground. In South America, north of the equator, the most excitable Mimosas were (next to Mimosa pudica), M. dormiens, M. somnians, and M. somniculosa. Theophrastus (iv. 3) and Pliny (xiii. 10) mention the irritability of the African sensitive plant; but I find the first description of the South American sensitive plants (Dormideras) in Herrera, Decad. II. lib. iii. cap. 4. The plant first attracted the attention of the Spaniards in 1518, in the savannahs on the isthmus near Nombre de Dios: "parece como cosa sensible;" and it was said that the leaves ("de echura de una pluma de pajaros") only contracted on being touched with the finger, and not if touched with a piece of wood. In the small swamps which surround the town of Mompox on the Magdalena, we discovered a beautiful aquatic Mimosacea (Desmanthus lacustris). It is figured in our Plantes équinoxiales, T. i.

p. 55, pl. 16. In the Andes of Caxamarca we found two Alpine Mimoseæ (Mimosa montana and Acacia revoluta), 8500 and 9000 French (about 9060 and 9590 English) feet above the surface of the Pacific.

Hitherto no true Mimosa (in the sense established by Willdenow), or even Inga, has been found in the temperate zone. Of all Acacias, the Oriental Acacia julibrissin, which Forskål has confounded with Mimosa arborea, is that which supports the greatest degree of cold. In the botanic garden of Padua there is in the open air a tree of this species with a stem of considerable thickness, although the mean temperature of Padua is below 10.°5 Reaumur (55°.6 Fahr.)

(19) p. 23.—"*Heaths.*"

In these physiognomic considerations we by no means comprise under the name of Heaths the whole of the natural family of Ericaceæ, which on account of the similarity and analogy of the floral parts includes Rhododendron, Befaria, Gaultheria, Escallonia, &c. We confine ourselves to the highly accordant and characteristic form of the species of Erica, including Calluna (Erica) Vulgaris, L., the common heather.

While, in Europe, Erica carnea, E. tetralix, E. cinerea, and Calluna vulgaris, cover large tracts of ground from the plains of Germany, France, and England to the extremity of Norway, South Africa offers the most varied assemblage of species. Only one species which is indigenous in the southern hemisphere at the Cape of Good Hope, Erica umbellata, is found in the northern hemisphere, *i. e.* in the

North of Africa, in Spain, and Portugal. Erica vagans and E. arborea also belong to the two opposite coasts of the Mediterranean: the first is found in North Africa, near Marseilles, in Sicily, Dalmatia, and even in England; the second in Spain, Italy, Istria, and in the Canaries." (Klotsch on the Geographical Distribution of species of Erica with persistent corollas, MSS.) The common heather, Calluna vulgaris, is a social plant covering large tracts from the mouth of the Scheldt to the western declivity of the Ural. Beyond the Ural, oaks and heaths cease together: both are entirely wanting in the whole of Northern Asia, and throughout Siberia to the shores of the Pacific Ocean. Gmelin (Flora Sibirica, T. iv. p. 129) and Pallas (Flora Rossica, T. i. Pars 2, p. 53) have expressed their astonishment at this disappearance of the Calluna vulgaris,—a disappearance which, on the eastern declivity of the Ural Mountains, is even more sudden and decided than might be inferred from the expressions of the last-named great naturalist. Pallas says merely: "ultra Uralense jugum sensim deficit, vix in Isetensibus campis rarissime apparet, et ulteriori Sibiriæ plane deest." Chamisso, Adolph Erman, and Heinrich Kittlitz, have found Andromedas indeed in Kamtschatka, and on the North West coast of America, but no Calluna. The accurate knowledge which we now possess of the mean temperature of several parts of Northern Asia, as well as of the distribution of the annual temperature into the different seasons of the year, affords no sort of explanation of the cessation of heather to the east of the Ural Mountains. Joseph Hooker, in a note to his Flora Antarctica, has treated and contrasted with great sagacity and clearness two very different phenomena which the distribution of plants presents to us: on the one hand, "uniformity of surface accompanied by a similarity of vegetation;" and on the other hand, "instances of a sudden change in the vegetation unaccompanied by any diversity of geological or other features." (Joseph Hooker, Botany of the Antarctic Voyage of the Erebus and Terror, 1844, p. 210.) Is there any species of Erica in Central Asia? The plant spoken of by Saunders in Turner's Travels to Thibet (Phil. Trans. Vol. lxxix. p. 86), as having been found in the Highlands of Nepaul (together with other European plants, Vaccinium myrtillus and V. oxycoccus) and described by him as Erica vulgaris, is believed by Robert Brown to have been an Andromeda, probably Andromeda fastigiata of Wallich. No less striking is the absence of Calluna vulgaris, and of all the species of Erica throughout all parts of the Continent of America, while the Calluna is found in the Azores and in Iceland. It has not hitherto been seen in Greenland, but was discovered a few years ago in Newfoundland. The natural family of the Ericaceæ is also almost entirely wanting in Australia, where it is replaced by Epacrideæ. Linnæus described only 102 species of the genus Erica; according to Klotzsch's examination, this genus really contains, after a careful exclusion of all mere varieties, 440 true species.

(20) p. 24.—"*The Cactus form.*"

If we take the natural family of the Opuntiaceæ separated from the Grossulariaceæ (the species of Ribes), and, viewed as it is by Kunth (Handbuch der Botanik, S. 609), we may well regard it as belonging exclusively to America. I am aware that Roxburgh, in the Flora Indica (inedita), cites two species of Cactus as belonging to South Eastern Asia;—Cactus indicus and C. chinensis. Both are widely disseminated, and are found in a wild state (whether they were originally wild or have become so), and are distinct from Cactus opuntia and C. coccinellifer; but it is remarkable that the Indian plant (Cactus indicus) has no ancient Sanscrit name. Cactus chinensis has been introduced in St. Helena as a cultivated plant. Now that a more general interest has at length been awakened on the subject of the original distribution of plants, future investigation will dispel the doubts which have been felt in several quarters respecting the existence of true Asiatic Opuntiaceæ. In the animal kingdom particular forms are found to occur singly. Tapirs were long regarded as a form exclusively characteristic of the New Continent; and yet the American tapir has been found as it were repeated in that of Malacca (Tapirus indicus, Cuv.)

Although the species of Cactus belong, generally speaking, more properly to the tropical regions, yet some are indigenous in the temperate zone, as on the Missouri and in Louisiana, Cactus missuriensis and C. vivipara; and Back saw with astonishment the shores of Rainy Lake, in north lat. 48° 40′, covered with C. opuntia. South of the equator the species of Cactus do not extend beyond the Rio Itata, in lat. 36°, and the Rio Biobio, in lat. 37° 15′. In the part of the Andes which is situated between the tropics, I have seen species of Cactus (C. sepium, C. chlorocarpus, C. bonplandii) growing on elevated plains nine or ten thousand (French) feet (about 9590 and 10660 English) above the level of the sea; but a still more alpine character is shewn in latitudes belonging to the temperate zone, in Chili, by the Opuntia ovallei, which has yellow flowers and a creeping stem. The upper and lower limits beyond which this plant does not extend have been accurately determined by barometric measurement by the learned botanist Claude Gay: it has never been found lower than 6330 French (6746 English) feet, and it reaches and even passes the limits of perpetual snow, having been found on uncovered masses of rock rising from amongst the snows. The last small plants were collected on spots situated 12820 French (13663 English) feet above the level of the sea. (Claudio Gay, Flora Chilensis, 1848, p. 30.) Some species of Echino-cactus are also true alpine plants in Chili. A counterpart to the fine-haired Cactus senilis is found in the thick-wooled Cereus lanatus, called by the natives Piscol, which has handsome red fruit. We found it in Peru, near Guancabamba, when on our journey to the Amazons river. The dimensions of the different kinds of Cactaceæ (a group on which the Prince of Salm-Dyck has been the first to throw great light) offer great variety and contrasts. Echinocactus wislizeni, which is 4 feet high and 7 feet in circumference (4 feet 3 inches and 7 feet 5 inches English), is still only the third in size, being surpassed by E. ingens

(Zucc.) and by E. platyceras (Lem.) (Wislizenus, Tour to Northern Mexico, 1848, p. 97.) The Echinocactus stainesii reaches from 2 to 2½ feet diameter; E. visnago, from Mexico, upwards of 4 English feet high, is above 3 English feet diameter, and weighs from 700 to 2000 lbs.: while Cactus nanus, which we found near Sondorillo, in the province of Jaen, is so small that, being only slightly rooted in the sand, it gets between the toes of dogs. The Melocactuses, which are full of juice in the dryest seasons like the Ravenala of Madagascar (forest-leaf in the language of the country, from *rave, raven,* a leaf, and *ala,* the Javanese *halas,* a forest), are vegetable fountains; and the manner in which the horses and mules stamp them open with their hoofs, at the risk of injury from the spines, has been already mentioned (Vol. I. p. 19). Since the last quarter of a century Cactus opuntia has extended itself in a remarkable manner into Northern Africa, Syria, Greece, and the whole of the South of Europe; even penetrating, in Africa, from the coasts far into the interior of the country, and associating itself with the indigenous plants.

When one has been accustomed to see Cactuses only in our hothouses, one is astonished at the degree of density and hardness which the ligneous fibres attain in old cactus stems. The Indians know that cactus wood is incorruptible, and excellent for oars and for the thresholds of doors. There is hardly anything in vegetable physiognomy which makes so singular and ineffaceable an impression on a newly arrived person, as the sight of an arid plain thickly covered, like those near Cumana, New Barcelona, and Coro, and in the province of Jaen de Bracamoros, with columnar and candelabra-like divided cactus stems.

(^{21}) p. 24.—"*Orchideæ.*"

The almost animal shape of blossoms of Orchideæ is particularly striking in the celebrated Torito of South America (our Anguloa grandiflora); in the Mosquito (our Restrepia antennifera); in the Flor del Espiritu Santo (also an Anguloa, according to Floræ Peruvianæ Prodrom. p. 118, tab. 26); in the ant-like flower of the Chiloglottis cornuta (Hooker, Flora antarctica, p. 69); in the Mexican Bletia speciosa; and in the highly curious host of our European species of Ophrys: O. muscifera, O. apifera, O. aranifera, O. arachnites, &c. A predilection for this superbly flowering group of plants has so increased, that the number cultivated in Europe by the brothers Loddiges in 1848 has been estimated at 2360 species; while in 1843 it was rather more than 1650, and in 1813 only 115. What a rich mine of still unknown superb flowering Orchideæ the interior of Africa must contain, if it is well watered! Lindley, in his fine work entitled "The Genera and Species of Orchideous Plants," described in 1840 precisely 1980 species; at the end of the year 1848 Klotzsch reckoned 3545 species.

While in the temperate and cold zones there are only "terrestrial" Orchideæ, *i. e.* growing on and close to the ground, tropical countries possess both forms, *i. e.* the "terrestrial" and the "parasitic," which grow on trunks of trees. To the first-named of these two divisions belong the tropical genera

Neottia, Cranichis, and most of the Habenarias. We have also found both forms growing as alpine plants on the slopes of the chain of the Andes of New Granada and Quito: of the parasitical Orchideæ (Epidendreæ), Masdevallia uniflora (at 9600 French, or about 10230 English feet); Cyrtochilum flexuosum (at 9480 French, or about 10100 English feet); and Dendrobium aggregatum (8900 French, or about 9480 English feet): and of the terrestrial Orchideæ, the Altensteinia paleacea, near Lloa Chiquito, at the foot of the Volcano of Pichincha. Claude Gay thinks that the Orchideæ said to have been seen growing on trees in the Island of Juan Fernandez, and even in Chiloe, were probably in reality only parasitical Pourretias, which extend at least as far south as 40° S. lat. In New Zealand we find that the tropical form of Orchideæ hanging from trees extends even to 45° S. lat. The Orchideæ of Auckland's and Campbell's Islands, however (Chiloglottis, Thelymitra, and Acianthus), grow on the ground in moss. In the animal kingdom, one tropical form at least advances much farther to the south. In Macquarie Island, in lat. 54° 39′, nearer to the South Pole therefore than Dantsie is to the North Pole, there is a native parrot. (See also the section Orchideæ in my work de Distrib. geogr. Plant., pp. 241-247.)

(22) p. 25.—"*The Casuarineæ.*"

Acacias which have phyllodias instead of leaves, some Myrtaceæ (Eucalyptus, Metrosideros, Melaleuca, and Leptospermum), and Casuarinas, give a uniform character to the vegetation of Australia and Tasmania (Van Diemen Island).

Casuarinas with their leafless, thin, string-like, articulated branches, having the joints provided with membranous denticulated sheaths, have been compared by travellers, according to the particular species which fell under their observation, either to arborescent Equisetaceæ (Horsetails) or to our Scotch firs. (See Darwin, Journal of Researches, p. 449.) Near the coast of Peru the aspect of small thickets of Colletia and Ephedra also produced on my mind a singular impression of leaflessness. Casuarina quadrivalvis advances, according to Labillardière, to 43° S. lat. in Tasmania. The sad-looking Casuarina form is not unknown in India and on the east coast of Africa.

(23) p. 25.—"*Needle-leaved trees.*"

The family of Coniferæ holds so important a place by the number of individuals, by their geographical distribution, and by the vast tracts of country in the northern temperate zone covered with trees of the same species living in society, that we are almost surprised at the small number of species of which it consists,—even including members which belong to it in essential respects, but deviate from it in a degree by the shape of their leaves and their manner of growth (Dammara, Ephedra, and Gnetum, of Java and New Guinea). The number of known Coniferæ is not quite equal to three-fourths of the number of described species of palms; and there are more known Aroideæ than Coniferæ. Zuccarini, in his Beiträgen zur Morphologie der Coniferen (Abhandl. der mathem. physikal. Classe der Akademie der Wiss. zu München, Bd. iii. S. 752, 1837-1843), reckons 216 species, of which 165 belong to the northern and 51 to the southern hemisphere. Since my researches these proportionate numbers must be modified, as, including the species of Pinus, Cupressus, Ephedra, and Podocarpus, found by Bonpland and myself in the tropical parts of Peru, Quito, New Granada, and Mexico, the number of species between the tropics rises to 42. The most recent and excellent work of Endlicher, Synopsis Coniferarum, 1847, contains 312 species now living, and 178 fossil species found in the coal measures, the bunter-sandstone, the keuper, and the Jurassic formations. The vegetation of the ancient world offers to us more particularly forms which, by their simultaneous affinity with several different families of the present vegetable world, remind us that many intermediate links have perished. Coniferæ abounded in the ancient world: their remains, belonging to an early epoch, are found especially in association with Palms and Cycadeæ; but in the latest beds of lignite we also find pines and firs associated as now with Cupuliferæ, maples, and poplars. (Kosmos, Bd. i. S. 295-298, and 468-470; Engl. edit. p. 271-274, and lxxxix.)

If the earth's surface did not rise to considerable elevations within the tropics, the highly characteristic form of needle-leaved trees would be almost unknown to the inhabitants of the equatorial zone. In common with Bonpland I have laboured much in the determination of the exact lower and upper limits of the region of Coniferæ and of oaks in the Mexican highlands. The heights at which both begin to grow (los Pinales y Encinales, Pineta et Querceta) are hailed with joy by those who come from the sea-coast, as indicating a climate where, so far as experience has hitherto shewn, the deadly malady of the black vomit (Vomito prieto, a form of yellow fever) does not reach. The lower limit of oaks, and more particularly of the Quercus xalapensis (one of the 22 Mexican species of oak first described by us), is on the road from Vera Cruz to the city of Mexico, a little below the Venta del Encero, 2860 (3048 E.) feet above the sea. On the western side of the highlands between the city of Mexico and the Pacific, the limit is rather lower down, for oaks begin to be found near a hut called Venta de la Moxonera, between Acapulco and Chilpanzingo, at an absolute elevation of 2328 (2480 E.) feet. I found a similar difference in the height of the lower limit of pine woods on the two sides of the continent. On the Pacific side, in the Alto de los Caxones north of Quaxiniquilapa, we found this limit for Pinus Montezumæ (Lamb.), which we at first took for Pinus occidentalis (Swartz), at an elevation of 3480 (3709 E.) feet; while towards Vera Cruz, on the Cuesta del Soldado, pines are first met with at a height of 5610 (5980 E.) feet. Therefore both the kinds of trees spoken of above, oaks and pines, descend lower on the side of the Pacific than they do on the side of the Antillean sea. In ascending the Cofre di Perote, I found the upper limit of the oaks 9715 (10354 E.) feet, and that of the Pinus Montezumæ at 12138 (12936 E.) feet above the sea, or almost 2000 (2132 E.) feet higher than the summit of Etna. Considerable quantities of snow had fallen at this elevation in the month of February.

The more considerable the heights at which the Mexican Coniferæ are first met with, the more striking it appears to find in the Island of Cuba (where, indeed, on the borders of the torrid zone, northern breezes sometimes cool the atmosphere down to 6½° Reaumur, 46°.6 Fah.), another species of pine (P. occidentalis of Swartz), growing in the plains or on the low hills of the Isla de Pinos, intermixed with palms and mahogany trees (Swietenias). Columbus mentions a small pine wood (Pinal) in the journal of his first voyage (Diario del 25 de Nov. 1492), near Cayo de Moya, on the north-east of the Island of Cuba. In Hayti also, Pinus occidentalis descends from the mountains to the sea-shore, near Cape Samana. The trunks of these Pines, carried by the Gulf-stream to the Islands of Graciosa and Fayal in the Azores, were among the chief indications from which the great discoverer inferred the existence of unknown lands to the west. (See my Examen crit., T. ii. p. 246—259.) Is it true that in Jamaica, notwithstanding the height of its mountains, Pinus occidentalis is entirely wanting? We may also ask what is the species of Pinus found on the eastern coast of Guatimala, as P. tenuifolia (Benth.) probably belongs only to the mountains near Chinanta?

If we cast a general glance on the species which form the upper limits of arborescent vegetation in the northern hemisphere, from the frigid zone to the equator, we find, beginning with Lapland, that according to Wahlenberg, on the Sulitelma Mountain (lat. 68°) it is not needle-trees which form the upper limit, but that birches (Betula alba) extend much higher up than Pinus sylvestris;—whilst in the temperate zone, in the Alps (lat. 45¾°), Pinus picea (Du Roi) advances highest, leaving the birches behind; and in the Pyrenees (lat. 42½°), Pinus uncinata (Ram.) and P. sylvestris var. rubra: within the tropics, in lat. 19°—20°, in Mexico, Pinus Montezumæ leaves far behind Alnus toluccensis, Quercus spicata, and Q. crassipes; while in the snow mountains of Quito at the equator, Escallonia myrtilloides, Aralia avicennifolia, and Drymis winteri, take the lead. The last-named tree, which is identical with Drymis granatensis (Mut.) and Wintera aromatica (Murray), presents, as Joseph Hooker has shewn (Flora Antarctica, p. 229), the striking example of the uninterrupted extension of the same species of tree from the most southern part of Tierra del Fuego and Hermit Island, where it was discovered by Drake's Expedition in 1577, to the northern highlands of Mexico; or through a range of 86 degrees of latitude, or 5160 geographical miles. Where it is not birches (as in the far north), but needle trees (as in the Swiss Alps and the Pyrenees), which form the limit of *arborescent* vegetation on the highest mountains, we find above them, still nearer to the snowy summits which they gracefully enwreath with their bright garlands, in Europe and Western Asia, the Alp roses, the Rhododendra,—which are replaced on the Silla de Caracas and in the Peruvian Paramo de Saraguru by the purple flowers of another genus of Ericaceæ, the beautiful race of Befarias. In Lapland the needle-trees are immediately followed by Rhododendron laponicum; in the Swiss Alps by Rhododendron ferrugineum and R. hirsutum; in the Pyrenees by the R. ferrugineum only; and in the Caucasus by

R. caucasicum. Decandolle found the Rhododendron ferrugineum growing singly in the Jura (in the Creux de Vent) at the moderate altitude of 3100 to 3500 (3304 to 3730 E.) feet, 5600 (5968 E.) feet lower down than its proper elevation. If we desire to trace the last zone of vegetation nearest to the snow line in the tropics, we must name, from our own observations, in the Mexican part of the tropical zone, Cnicus nivalis and Chelone gentianoides; in the cold mountain regions of New Granada, the woolly Espeletia grandiflora, E. corymbosa and E. argentea; and in the Andes of Quito, Culcitium rufescens, C. ledifolium, and C. nivale,—yellow flowering Compositæ which replace in the last-named mountains the somewhat more northerly Espeletias of New Granada, to which they bear a strong physiognomic resemblance. This replacement, the repetition of resembling or almost similar forms in countries separated either by seas or by extensive tracts of land, is a wonderful law of nature which appears to prevail even in regard to some of the rarest forms of vegetation. In Robert Brown's family of the Rafflesieæ, separated from the Cytineæ, the two Hydnoras described by Thunberg and Drege in South Africa (H. africana and H. triceps) have their counterpart in South America in Hydnora americana (Hooker).

Far above the region of alpine plants, grasses, and lichens, and even above the limit of perpetual snow, the botanist sees with astonishment, both in the temperate and tropical zones, isolated phænogamous plants occur now and then sporadically on rocks which remain free from the general surrounding snowy covering, and which may possibly be warmed by heat ascending through open fissures. I have already spoken of the Saxifraga boussingaulti, which is found on the Chimborazo at an elevation of 14800 (15773 E.) feet; in the Swiss Alps, Silene acaulis has been seen at a height of 10680 (11380 E.) feet, being in the first-named case 600 (640 E.) feet, and in the second 2460 (2620 E.) feet above the limit of the snows, that limit being taken as it was in the two cases respectively at the time when the plants were found.

In our European Coniferæ, the Red and White Pine shew great and remarkable differences in respect to their distribution. While in the Swiss Alps the Red Pine (Pinus picea, Du Roi, foliis compresso—tetragonis; unfortunately called by Linnæus, and by most of the botanists of the present day, Pinus abies!) forms the upper limit of arborescent vegetation at a mean height of 5520 (5883 English) feet, only an occasional low growing mountain-alder (Alnus viridis, Dec., Betula viridis, Vill.) advancing now and then still nearer to the snow-line; the White Pine (Pinus abies, Du Roi, Pinus picea, Linn., foliis planis, pectinato-distichis, emarginatis) ceases, according to Wahlenberg, more than a thousand feet lower down. The Red Pine does not appear at all in the South of Europe, in Spain, the Appennines, and Greece; even on the northern slope of the Pyrenees it is seen only, as Ramond remarks, at great elevations, and is entirely wanting in the Caucasus. The Red Pine advances in Scandinavia farther to the north than the White Pine, of which last-named tree there is in Greece (on Mounts Parnassus, Taygetus, and Œta) a long needled variety (foliis apice integris, breviter mucronatis), the Abies Apollinis of Link. (Linnæa, Bd. xv. 1841, S. 529; and Endlicher, Synopsis Coniferarum, p. 96.)

On the Himalaya the Coniferæ are distinguished by the great thickness and height of their trunks, and by the length of their leaves. The Deodwara Cedar, Pinus deodara (Roxb.),—(properly, in Sanscrit, dêwa-dâru, timber of the Gods),—which is from 12 to 13½ feet thick, is the great ornament of the mountains. It grows in Nepaul to 11000 (11720 E.) feet above the level of the sea. More than 2000 years ago the Deodara supplied the materials for the fleet of Nearchus on the Hydaspes (the present Behut). In the valley of Dudegaon, north of the copper mines of Dhunpour in Nepaul, Dr. Hoffmeister, so early lost to science, found the Pinus longifolia of Royle (the Tschelu Pine) growing among tall stems of the Chamærops martiana of Wallich. (Hoffmeister's Briefe aus Indien wahrend der Expedition des Prinzen Waldemar von Preussen, 1847, S. 351.) Such an intermixture of pineta and palmata had excited the surprise of the companions of Columbus in the New Continent, as a friend and cotemporary of the Admiral, Petrus Martyr Anghiera, has informed us. (Dec. iii. lib. 10, p. 68.) I saw myself this intermixture of pines and palms for the first time on the road from Acapulco to Chilpanzingo. The Himalaya, like the Mexican highlands, has, besides Pines and Cedars, also the forms of Cypresses (Cupressus torulosa (Don), of Yews (Taxus wallichiana, Zuccar.), of Podocarpus (P. nereifolia, Robert Brown), and of

Juniper (Juniperus squamata, Don., and J. excelsa, Bieberst; Juniperus excelsa is also found at Schipke in Thibet, in Asia Minor, in Syria, and in the Greek Islands). Thuja, Taxodium, Larix, and Araucaria, are forms found in the New Continent, but wanting in the Himalaya.

Besides the 20 species of Pines which we already know from Mexico, the United States of North America, which in their present extent reach to the Shores of the Pacific, have 45 described species, while Europe has only 15. There is a similar difference in respect to Oaks: *i. e.* greater variety of forms in the New Continent which extends continuously through a greater extent of latitude. The recent very exact researches of Siebold and Zuccarini have, however, completely refuted the previous belief, that many European species of Pines extend also across the whole of Northern Asia to the Islands of Japan, and even grow there, interspersed, as Thunberg has stated, with genuine Mexican species, the Weymouth Pine, Pinus Strobus of Linnæus. What Thunberg took for European Pines are wholly different and distinct species. Thunberg's Red Pine (Pinus abies, Linn.) is P. polita, (Sieb.) and is often planted near Buddhistic temples; his common Scotch Fir (Pinus sylvestris) is P. Massoniana (Lamb.); his P. cembra (the German and Siberian pine with eatable seeds) is P. parviflora (Sieb.); his common Larch (P. larix) is P. leptolepis (Sieb.); and his supposed Taxus baccata, the fruits of which are eaten by Japanese courtiers in case of long-protracted court ceremonials, (Thunberg, Flora Japonica, p. 275), constitutes a distinct genus, and is the Cephalotaxus drupacea of Siebold.

The Islands of Japan, notwithstanding the vicinity of the Continent of Asia, have a very distinct character of vegetation. Thunberg's supposed Japanese Weymouth Pine, (Pinus Strobus) which would offer an important phenomenon, is only a planted tree, and is besides quite distinct from the American species of Pine. It is Pinus korajensis (Sieb.), and has been brought to Nipon from the peninsula of Corea, and from Kamtschatka.

Of the 114 species of the Genus Pinus with which we are at present acquainted, not one belongs to the Southern Hemisphere, for the Pinus merkusii described by Junghuhn and De Vriese belongs to the part of the Island of Sumatra which is north of the Equator, to the district of the Battas; and Pinus insularis (Endl.) although it was at first given in Loudon's Arboretum as P. timoriensis, really belongs to the Philippines. Besides the Genus Pinus, the Southern hemisphere, according to the present state of our now happily advancing knowledge of the geography of plants, is entirely without species of Cupressus, Salisburia (Gingko), Cunninghamia (Pinus lanceolota, Lamb.) Thuja, (one of the species of which, Th. gigantea, Nutt., found on the banks of the Columbia, has a height of above 180 Eng. feet), Juniperus, and Taxodium (Mirbel's Schubertia). I include the last-named genus with the less hesitation, as a Cape of Good Hope plant (Sprengel's Schubertia capensis) is no Taxodium, but constitutes a genus of itself, Widringtonia, (Endl.) in quite a different division of the family of Coniferæ.

This absence, from the Southern Hemisphere, of true Abietineæ, Juniperineæ, Cupressineæ, and all the Taxodineæ, as well as of Torreya, Salisburia adiantifolia, and Cephalotaxus from among the Taxineæ, recalls forcibly the obscurity which still prevails in the conditions which have determined the original distribution of vegetable forms, a distribution which cannot be sufficiently and satisfactorily explained solely by similarity or diversity of soil, thermic relations, or meteorological phenomena. I remarked long ago that the Southern Hemisphere for example has many plants belonging to the natural family of Rosaceæ, but not a single species of the genus Rosa. We learn from Claude Gay that the Rosa chilensis described by Meyen is only a wild variety of the Rosa centifolia (Linn.), which has been for thousands of years a European plant. Such wild varieties, (*i. e.* varieties which have become wild) occupy large tracts of ground in Chili, near Valdivia and Osorno. (Gay, Flora Chilensis, p. 340.)

In the tropical region of the Northern hemisphere we also found only one single native rose, our Rosa montezumæ, in the Mexican highlands near Moran, at an elevation of 8760 (9336 Engl.) feet. It is one of the singular phenomena in the distribution of plants, that Chili, which has Palms, Pourretias, and many species of Cactus, has no Agave; although A. americana grows luxuriantly in Roussillon, near Nice, near Botzen and in Istria, having probably been introduced from the New Continent since the end of the 16th century, and in America itself forms a continuous tract of vegetation from Northern Mexico across the isthmus of Panama to the Southern part of Peru. I have long believed that Calceolarias were limited like Roses exclusively to one side of the Equator; of the 22 species which we brought back with us, not one was collected to the north of Quito and the Volcano of Pichincha; but my friend Professor Kunth remarks that Calceolaria perfoliata, which Boussingault and Captain Hall found at Quito, advances to New Granada, and that this species, as well as C. integrifolia of Santa Fé de Bogotá, were given by Mutis to the great Linnæus.

The species of Pinus which are so frequent in the tropical Antilles and in the tropical mountains of Mexico do not pass the isthmus of Panama, and are not found in the equally mountainous parts of the tropical portion of South America, and in the high plains of New Granada, Pasto, and Quito. I have been both in the plains and on the mountains from the Rio Sinu, near the isthmus of Panama, to 12° S. lat.; and in this tract of almost 1600 geographical miles the only forms of needle-trees which I saw were a Taxus-like species of Podocarpus with stems 60 (64 Eng.) feet high (Podocarpus taxifolia), growing in the Pass of Quindiu and in the Paramo de Saraguru, in 4° 26′ north, and 3° 40′ south latitude; and an Ephedra (E. americana) near Guallabamba, north of Quito.

Among the Coniferæ there are common to the northern and southern hemispheres the genera Taxus, Gnetum, Ephedra, and Podocarpus. The last-named genus was distinguished from Pinus long before L'Heritier by Columbus himself, who wrote on the 25th of November, 1492: "Pinales en la Serrania de Haiti que no llevan piñas, pero frutos que parecen azeytunos del Axarafe de Sevilla." (See my Examen crit. T. iii. p. 24.) There are species of Taxus from the Cape of Good Hope to 61° N. lat. in Scandinavia, or through more than 95 degrees of latitude; Podocarpus and Ephedra extend almost as far. In Cupuliferæ, the species of oak which we are accustomed to regard as a northern form do not indeed pass beyond the equator in South America, but in the Indian Archipelago they re-appear in the southern hemisphere in the Island of Java. To the southern hemisphere belong exclusively ten genera of Coniferæ, of which I will name here only the principal: Araucaria, Dammara (Agathis Sal.), Frenela (with eighteen New Holland species), Dacrydium and Lybocedrus, which is found both in New Zealand and at the Straits of Magellan. New Zealand has one species of the genus Dammara (D. australis) and no Araucaria. In New Holland in singular contrast the case is opposite.

Among tree vegetation, it is in the form of needle-trees that Nature presents to us the greatest extension in length (longitudinal axis): I say among tree vegetation, because, as we have already remarked, among oceanic Algæ, Macrocystis pyrifera, which is found between the coast of California and 68° S. lat., often attains from 370 to 400 (about 400 to 430 Eng.) feet in length. Of Coniferæ, (setting aside the six Araucarias of Brazil, Chili, New Holland, Norfolk Island, and New Caledonia), the loftiest are those which belong to the northern temperate zone. As in the family of Palms we found the most gigantic, the Ceroxylon andicola, above 180 French (192 English) feet high, in the temperate mountain climate of the Andes, so the loftiest Coniferæ belong, in the northern hemisphere, to the temperate north-west coast of America and to the Rocky Mountains (lat. 40°–52°); and in the southern hemisphere to New Zealand, Tasmania or Van Diemen Island, the south of Chili and Patagonia (between 43° and 50° latitude). The most gigantic forms belong to the genera of Pinus, Sequoia (Endl.), Araucaria, and Dacrydium. I propose to name only those species which not only attain but often exceed 200 French feet (213 Eng.) In order to afford a standard of comparison, it should be remarked that in Europe the tallest Red and White Pines, the latter especially, attain about 150 or 160 (160—170 Eng.) feet; that, for example, in Silesia the Pine of the Lampersdorf Forest near Frankenstein enjoys great celebrity, although, with a circumference of 17 English feet, its height is only 153 Prussian, or 148 French, or 158 English feet. (Compare Ratzeburg, Forstreisen, 1844, S. 287.)

Pinus grandis (Douglas) in New California attains 224 English feet.

Pinus frémontiana (Endl.), also in New California, probably attains the same stature as the preceding. (Torrey and Frémont, Report of the Exploring Expedition to the Rocky Mountains in 1844, p. 319.)

Dacrydium cupressinum (Solander), from New Zealand, 213 English feet.

Pinus lambertiana (Dougl.), in North-west America, 224—235 English feet.

Araucaria excelsa (R. Brown), the Cupressus columnaris of Forster, in Norfolk Island and the surrounding rocky islets, 181—224 English feet. The six species of Araucaria which have become known to us hitherto, fall, according to Endlicher, into two groups :

a. The American group (Brazil and Chili) : A. brasiliensis (Rich.), between 15° and 25° S. lat. ; and A. imbricata (Pavon), between 35° and 50° S. lat., the latter growing to 234—260 English feet.

b. The Australian group : A. bidwilli (Hook.) and A. cunninghami (Ait.) on the east side of New Holland ; A. excelsa on Norfolk Island, and A. cookii (R. Brown) in New Caledonia. Corda, Presl. Göppert, and Endlicher, have already discovered five species of Araucarias belonging to the ancient world in the lias, in chalk, and in beds of lignite (Endlicher, Coniferæ fossiles, p. 301.)

Pinus Douglasii (Sabine), in the valleys of the Rocky Mountains and on the banks of the Columbia River (north lat. 43°—52°). The meritorious Scotch botanist from whom this tree is named perished in 1833 by a dreadful death in collecting plants in the Sandwich Islands, where he had arrived from New California. He fell inadvertently into a pit in which a fierce bull belonging to the cattle which have become wild had previously fallen, and was gored and trampled to death. By exact measurement a stem of Pinus Douglasii was 57½ English feet in girth at 3 feet above the ground, and its height was 245 English feet. (See Journal of the Royal Institution, 1826, p. 325.)

Pinus trigona (Rafinesque), on the western declivity of the Rocky Mountains, described in Lewis and Clarke's Travels to the Source of the Missouri River and across the American Continent to the Pacific Ocean (1804—1806), 1814, p. 456. This gigantic Fir was measured with great care ; the trunks were often 38 to 45 English feet in girth, 6 feet above the ground: one tree was 300 English feet high, and the first 192 feet were without any division into branches.

Pinus Strobus grows in the eastern parts of the United States of North America, especially on the east of the Mississipi; but it is found again in the Rocky Mountains from the sources of the Columbia to Mount Hood, or from 43° to 54° N. lat. It is called in Europe the Weymouth Pine and in North America the White Pine: its ordinary height does not exceed 160 to 192 Eng. feet, but several trees of 250 to 266 Eng. feet have been seen in New Hampshire. (Dwight, Travels, Vol. i. p. 36; and Emerson's Report on the Trees and Shrubs growing naturally in the Forests of Massachusetts, 1846, p. 60-66.)

Sequoia gigantea (Endl.), Condylocarpus (Sal.) from New California; like Pinus trigona, about 300 English feet high.

The nature of the soil, and the circumstances of heat and moisture on which the nourishment of plants depend, no doubt influence the degree to which they flourish, and the increase in the number of individuals in a species; but the gigantic height attained by the trunks of a few among the many other nearly allied species of the same genus, depends not on soil or climate; but, in the vegetable as well as in the animal kingdom, on a specific organisation and inherent natural disposition. I will cite as the greatest contrast to the Araucaria imbricata of Chili, the Pinus Douglasii of the Columbia River, and the Sequoia gigantea of New California, which is from 245 to 300 Eng.

feet in height,—not a plant taken from among a vegetation stunted by cold either of latitude or elevation, as is the case with the small Willow-tree, two inches in height, (Salix arctica),—but a small phænogamous plant belonging to the fine climate of the southern tropic in the Brazilian province of Goyaz. The moss-like Tristicha hypnoïdes, from the monocotyledonous family of the Podostemeæ, hardly reaches the height of 3 lines ($\frac{27}{100}$ths, or less than three-tenths of an English inch.) "En traversant le Rio Claro dans la Province de Goyaz," says an excellent observer, Auguste de St.-Hilaire, "j'aperçus sur une pierre une plante dont la tige n'avoit pas plus de trois lignes de haut et que je pris d'abord pour une mousse. C'étoit cependant une plante phanérogame, le Tristicha hypnoïdes, pourvue d'organes sexuels comme nos chênes et les arbres gigantesques qui à l'entour élevaient leur cimes majestueuses." (Auguste de St.-Hilaire, Morphologie Végétale, 1840, p. 98.)

Besides the height of their stems, the length, breadth, and position of the leaves and fruit, the form of the ramification aspiring or horizontal, and spreading out like a canopy or umbrella,—the gradations of colour, from a fresh green or silvery grey to a blackish-brown, all give to Coniferæ a peculiar physiognomy and character. The needles of Douglas's Pinus lambertiana from North-west America are five French inches long; those of Pinus excelsa of Wallich, on the southern declivity of the Himalaya, near Katmandoo, seven French inches; and those of P. longifolia (Roxb.), from the mountains of Kashmeer, above a French foot long. In one and the same species the length of the leaves or needles varies in the most striking manner from the influence of soil, air, and elevation above the level of the sea. In travelling in an east and west direction through eighty degrees of longitude (above 3040 geographical miles), from the mouth of the Scheldt through Europe and the north of Asia to Bogoslowsk in the northern Ural and Barnaul beyond the Obi, I have found differences in the length of the needles of our common Fir (Pinus sylvestris) so great, that sometimes a traveller may be misled by the shortness and rigidity of the leaves, to think that he has discovered a new species allied to the Mountain Pine, P. rotundata (Link), P. uncinata (Ram.) Link has justly remarked (Linnæa, Bd. xv. 1841, S. 489) that such instances may be regarded as transitions to Ledebour's P. sibirica of the Altai.

In the Mexican highlands I have looked with particular pleasure on the delicate cheerful green of the Ahuahuete, Taxodium distichum (Rich.), Cupressus disticha (Linn.), which, however, is much given to shedding its leaves. In this tropical region the above-mentioned tree, (of which the Aztec name signifies water-drum, from *atl*, water, and *huehuetl*, a drum, the trunk swelling to a great thickness), flourishes 5400 and 7200 (5755 and 7673 English) feet above the level of the sea, while in the United States of North America it is found in the low grounds of the cypress swamps of Louisiana, in the 43d parallel. In the Southern States of North America the Taxodium distichum (Cyprès chauve) reaches, as in the Mexican highlands, the height of 120 (128 English) feet, and the enormous thickness of 30 to 37 (32 to 39 English) feet, in diameter measured near the ground. (Emerson, Report on the Forests, pp. 49 and 101). The roots present the striking phenomenon of woody excrescences which project from 3 to 4½ feet above the earth, and are conical and rounded, and sometimes tabular. Travellers have compared these excrescences in places where they are very numerous to the grave tablets in a Jewish burying-ground. Auguste de St. Hilaire remarks with much acuteness :—"Ces excroissances du Cyprès chauve, ressemblant à des bornes, peuvent être regardées comme des exostoses, et comme elles vivent dans l'air, il s'en échapperoit sans doute des bourgeons adventifs, si la nature du tissu des plantes conifères ne s'opposoit au développement des germes cachés qui donnent naissance à ces sortes de bourgeons." (Morphologie végétale, p. 91). A singularly enduring power of vitality in the roots of trees of this family is shown by a phenomenon which has excited the attention of vegetable physiologists, and appears to be of only very rare occurrence in other dicotyledonous trees. The remaining stumps of White Pines which have been cut down continue for several years to make fresh layers of wood, and to increase in thickness, without putting forth new shoots, leaves, or branches. Göppert believes that this only takes place by means of root nourishment received by the stump from a neighbouring living tree of the same species; the roots of the living individual which has branches and leaves having become organically united with those of the cut tree by their having grown together. (Göppert, Beobachtungen über das sogenannte Umwallen der Tännen-stöcke, 1842, S. 12). Kunth, in his excellent new "Lehrbuch der Botanik," objects to this explanation of a phenomenon which was known, imperfectly, so early as Theophrastus. (Hist. Plant. lib. iii. cap. 7, pp. 59 and 60, Schneider.) He considers the case to be analogous to what takes place when metal-plates, nails, carved letters, and even the antlers of stags, become enclosed in the wood of a growing tree. "The cambium, *i. e.* the viscid secretion out of which new elementary organs are constructed either of woody or cellular tissue, continues, without reference to the buds (and quite apart from them), to deposit new layers of wood on the outermost layer of the ligneous substance." (Th. i. S. 143 and 166.)

The relations which have been alluded to, between elevation above the level of the sea and geographical and thermal latitude, manifest themselves often when we compare the tree vegetation of the tropical part of the chain of the Andes with the vegetation of the north-west coast of America, or with that of the shores of the Canadian Lakes. Darwin and Claude Gay have made the same remark in the Southern Hemisphere, in advancing from the high plains of Chili to Eastern Patagonia and Tierra del Fuego, where they found Drymis winteri and forests of Fagus antarctica and Fagus forsteri forming a uniform covering throughout long continuous lines running from north to south and descending to the low grounds. We find even in Europe small deviations (dependent on local causes which have not yet been sufficiently examined), from the law of constant ratio as regards stations or habitat of plants between elevation above the sea and geographical latitude. I would recall the limits, in respect to elevation, of the birch and the common fir in a part of the Swiss Alps, on the Grimsel. The fir (Pinus sylvestris) extends to 5940, and the birch (Betula alba) to 6480 French (6330 and 6906 English) feet; above the birches there is a higher line of Pinus cembra, whose upper limit is 6890 (7343 English) feet. Here, therefore, we have the birch intervening between two zones of Coniferæ. According to the excellent observations of Leopold Von Buch, and the recent ones of Martins, who also visited Spitzbergen, the following geographical limits were found in Lapland:—Pinus sylvestris extends to 70°; Betula alba to 70° 40′; and Betula nana quite up to 71°; Pinus cembra is altogether wanting in Lapland. (Compare Unger über den Einfluss des Bodens auf die Vertheilung der Gewächse, S. 200; Lindblom, Adnot. in geographicam plantarum intra Sueciam distributionem, p. 89; Martins, in the Annales des Sciences naturelles, T. xviii. 1842, p. 195).

If the length and arrangement of the needle-shaped leaves go far to determine the physiognomic character of Coniferæ, this character is still more influenced by the specific differences in the breadth of the needles, and the degree of development of the parenchyma of the appendicular organs. Several species of Ephedra may be called almost leafless; but in Taxus, Araucaria, Dammara (Agathis), and the Salisburia adiantifolia of Smith (Gingko biloba, Linn.), the surfaces of the leaves become gradually broader. I have here placed the genera in morphological succession. The specific names first chosen by botanists testify in favour of such a succession. The Dammara orientalis of Borneo and Java, often above ten feet in diameter, was first called loranthifolia; and Dammara australis (Lamb.) of New Zealand, which is 140 (149 English) feet high, was first called zamæfolia. In both these species of trees the leaves are not needles, but "folia alterna oblongo-lanceolata, opposita, in arbore adultiore sæpe alterna, enervia, striata." The under surface of the leaves is thickly set with porous openings. This passage or transition of the appendicular system from the greatest contraction to a broad-leaved surface, like all progression from simple to compound, has at once a morphological and a physiognomic interest (Link, Urwelt, Th. I. 1834, S. 201—211). The short-stalked, broad, cleft leaf of the Salisburia (Kämpfer's Gingko) has also its breathing pores only on the under side of the leaf. The original native country of this tree is unknown to us. By the connection and intercourse of Buddhistic communities it early passed from the temple-gardens of China to those of Japan.

In travelling from a port on the Pacific to Mexico, on our way to Europe, I witnessed the singular and painful impression which the first sight of a pine forest near Chilpanzingo made on one of our companions, who, born at Quito under the equinoctial line, had never seen needle trees, or trees with "folia acerosa." It seemed to him as if the trees were leafless; and he thought that as we were travelling towards the cold North, he already recognised in this extreme contraction of the vegetable organs the chilling and impoverishing influence of the pole. The traveller whose impressions I here describe, whose name neither my friend Bonpland or myself can pronounce without regret, was Don Carlos Montufar (son of the Marquis of Selvalegre), an excellent young man, whose noble and ardent love of freedom led him a few years later, in the war of independence of the Spanish Colonies, to meet courageously a violent death, of which the dishonour did not fall on him.

(24) p. 26.—"*The Pothos-form, Aroideæ.*"

Caladium and Pothos are exclusively forms of the tropical world; the species of Arum belong more to the temperate zone. Arum italicum, A. dracunculus, and A. tenuifolium, extend to Istria and Friuli. No Pothos has yet been discovered in Africa. India has some species of this genus (Pothos scandens and P. pinnata) which are less beautiful in their physiognomy, and less luxuriant in their growth, than the American species. We discovered a beautiful and truly arborescent member of the group of Aroideæ (Caladium arboreum) having stems from 16 to 21 English feet high, not far from the convent of Caripe, to the East of Cumanas. A very curious Caladium (Culcasia scandens) has been discovered by Beauvois in the kingdom of Benin. (Palisot de Beauvois, Flore d'Oware et de Benin, T. i. 1804, p. 4, pl. iii.) In the Pothos-form the parenchyma is sometimes so much extended that the surface of the leaf is interrupted by holes as in Calla pertusa (Kunth), and Dracontium pertusum (Jacquin), which we collected in the woods round Cumana. The Aroideæ first led attention to the remarkable phenomenon of the fever-heat, which in certain plants is sensible by the thermometer during the development of their inflorescence, and which is connected with a great and temporary increase of the absorption of oxygen from the atmosphere. Lamarck remarked in 1789 this increase of temperature at the time of flowering in Arum italicum. According to Hubert and Bory de St. Vincent the vital heat of Arum cordifolium in the Isle of France was found to rise to 35° and 39° Reaumur, (110°.6 and 119°.6 Fahr.) while the temperature of the surrounding air was only 15°.2 R. (66°.2 F.) Even in Europe, Becquerel and Breschet found as much as 17½° difference, Reaumur (39°.4 Fahr.) Dutrochet remarked a paroxysm, an alternate decrease and increase of vital heat, which appeared to reach a double maximum in the day. Théodore de Saussure observed analogous augmentations of temperature, though to a less amount, only from 0°.5 to 0°.8 of Reaumur's scale (1°.15 to 1°.8 Fahr.), in plants belonging to other families; for example, in Bignonia radicans and Cucurbita pepo. In the latter plant the use of a very sensitive thermoscope shews that the increase of temperature is greater in the male than in the female plant. Dutrochet, who previous to his early death made such meritorious researches in physics and in vegetable physiology, found by means of thermo-magnetic multiplicators (Comptes rendus de l'Institut, T. viii. 1839, p. 454, T. ix. p. 614 and 781) an increase of vital heat from 0°.1 to 0°.3 Reaumur, (0°.25 to 0°.67 Fahr.) in several young plants (Euphorbia lathyris, Lilium candidum, Papaver somniferum), and even among funguses in several species of Agaricus and Lycoperdon.

This vital heat disappeared at night, but was not prevented by placing the plants in the dark during the day-time.

A yet more striking physiognomic contrast than that of Casuarineæ, Needle trees, and the almost leafless Peruvian Colletias, with Aroideæ, is presented by the comparison of those types of the greatest contraction of the leafy organs with the Nymphæaceæ and Nelumboneæ. We find in these as in the Aroideæ, leaves, in which the cellular tissue forming their surface is extended to an extreme degree, supported on long fleshy succulent leaf-stalks; as in Nymphæa alba; N. lutea; N. thermalis (once called N. lotus, from the hot spring of Pezce near Groswardein, in Hungary); the species of Nelumbo; Euryale amazonica of Pöppig; and the Victoria Regina discovered in 1837 by Sir Robert Schomburgk in the River Berbice in British Guiana, and which is allied to the prickly Euryale, although, according to Lindley, a very different genus. The round leaves of this magnificent water plant are six feet in diameter, and are surrounded by turned up margins 3 to 5 inches high, light green inside, and bright crimson outside. The agreeably perfumed flowers, twenty or thirty blossoms of which may be seen at the same time within a small space, are white and rose coloured, 15 inches in diameter, and have many hundred petals. (Rob. Schomburgk, Reisen in Guiana und am Orinoko, 1841, S. 233.) Pöppig also gives to the leaves of his Euryale amazonica which he found near Tefe, as much as 5 feet 8 inches French, or 6 English feet, diameter. (Pöppig, Reise in Chile, Peru und auf dem Amazonenstrome, Bd. ii. 1836, S. 432.) If Euryale and

Victoria are the genera which present the greatest extension in all dimensions of the parenchyma of the *leaves*, the greatest known dimensions of a *flower* belong to a parasitical Cytinea, the Rafflesia Arnoldi (R. Brown), discovered by Dr. Arnold in Sumatra, in 1818: it has a stemless flower of three English feet diameter, surrounded by large leaf-like scales. Fungus-like, it has an animal smell, resembling beef.

(25) p. 26.—"*Lianes, rope-plants,* ('*Bush ropes;*' *in Spanish, Vejuccos.*")

According to Kunth's division of the Bauhinieæ, the true genus Bauhinia belongs to the New Continent: the African Bauhinia, B. rufescens, (Lam.) is a Pauletia (Cav.) a genus of which we found some new species in South America. So also the Banisterias, from among the Malpighiaceæ, are properly an American form; although two species are natives of India, and one species, Banisteria leona, described by Cavanilles, is a native of Western Africa. Within the tropics and in the Southern Hemisphere we find among the most different families of plants the twining rope-like climbers which in those regions render the forests at once so impenetrable to man, and on the other hand so accessible and habitable to the Quadrumanæ (or Monkeys) and to the Cercoleptes and the small tiger-cats. The rapid ascent to the tops of lofty trees, the passage from tree to tree, and even the crossing of streams by whole herds or troops of gregarious animals, are all greatly facilitated by these twining plants or Lianes.

In the South of Europe and in North America, Hops from among the Urticeæ, and the species of Vitis from among the Ampelideæ, belong to the class of twining climbers, and between the tropics we find climbing Grasses or Gramineæ. We have seen in the plains of Bogota, in the pass of Quindiu, in the Andes, and in the Quina-producing forests of Loxa, a Bambusacea allied to Nastus, our Chusquea scandens, twine round massive and lofty trunks of trees adorned at the same time with flowering Orchideæ. The Bambusa scandens (Tjankorreh), which Blume found in Java, belongs probably either to the genus Nastus or to that of Chusquea, the Carrizo of the Spanish settlers. Twining plants appear to me to be entirely absent in the Pine-woods of Mexico, but in New Zealand, besides the Ripogonum parviflorum of Robert Brown, (a climber belonging to the Smilaceæ which renders the forests almost impenetrable), the sweet-smelling Freycinetia Banksii, which belongs to the Pandaneæ, twines round a gigantic Podocarpus 220 English feet high, the P. dacryoides (Rich), called in the native language Kakikatea. (Dieffenbach, Travels in New Zealand, 1843, Vol. i. p. 426.)

With climbing Gramineæ and Pandaneæ are contrasted by their beautiful and many-coloured blossoms the Passifloras (among which, however, we even found an arborescent self-supporting species, Passiflora glauca, growing in the Andes of Popayan, at an elevation of 9840 French (10487 English) feet) ;—the Bignoniaceæ, Mutisias, Alströmerias, Urvilleæ, and Aristolochias. Among the latter our Aristolochia cordata has a crimson-coloured flower of 17 English inches diameter ! "flores gigantei, pueris mitræ instar inservientes." Many of these twining plants have a peculiar physiognomy and appearance produced by the square shape of their stems, by flattenings not caused by any external pressure, and by riband-like wavings to and fro. Cross sections of Bignonias and Banisterias shew cruciform or mosaic figures produced by the mutual pressure and interpenetration of the stems which twine around each other. (See very accurate drawings in Adrien de Jussieu's Cours de Botanique, p. 77-79, fig. 105-108.)

(26) p. 27.—“*The form of Aloës.*”

To this group of plants, characterised by so great a similarity of physiognomy, belong; Yucca aloifolia, which extends as far north as Florida and South Carolina; Y. angustifolia (Nutt.) which advances as far as the banks of the Missouri; Aletris arborea; the Dragon-tree of the Canaries and two other Dræcænas from New Zealand; arborescent Euphorbias; Aloë dichotoma (Linn.) (formerly the genus Rhipidodendrum of Willdenow); and the celebrated Koker-boom of Southern Africa with a trunk twenty-one feet high and above four feet thick, and a top of 400 (426 Engl.) feet in circumference. (Patterson, Reisen in das Land der Hottentotten und der Kaffern, 1790, S. 55.) The forms which I have thus brought together belong to very different families: to the Liliaceæ, Asphodeleæ, Pandaneæ, Amaryllideæ, and Euphorbiaceæ; all, however, with the exception of the last, belonging to the great division of the Monocotyledones. A Pandanea, Phytelephas macrocarpa (Ruiz,) which we found in New Granada on the banks of the Magdalena, with its pinnated leaves, quite resembles in appearance a small palm-tree. This Phytelephas, of which the Indian name is Tagua, is besides, as Kunth remarks, the only one of the Pandaneæ found (according to our present knowledge) in the New Continent. The singular Agave-like and at the same time very tall-stemmed Doryanthes excelsa of New South Wales, which was first described by the acutely observing Correa de Serra, is an Amaryllidea, like our low-growing Narcissuses and Jonquils.

In the Candelabra shape of plants of the Aloë form, we must not confound the branches of an arborescent stem with flower-stalks. It is the latter which in the American Aloë (Agave Americana, Maguey de Cocuyza, which is entirely wanting in Chili) as well as in the Yucca acaulis, (Maguey de Cocuy) presents in the rapid and gigantic development of the inflorescence a candelabrum-like arrangement of the flowers which, as is well known, is but too transient a phenomenon. In some arborescent Euphorbias, on the other hand, the physiognomic effect is given by the branches and their division, or by ramification properly so called. Lichtenstein, in his "Reisen im südlichen Africa" (Th. i. S. 370), gives a vivid description of the impression made upon him by the appearance of a Euphorbia officinarum which he found in the "Chamtoos Rivier," in the Colony of the Cape of Good Hope; the form of the tree was so symmetrical that the candelabrum-like arrangement was regularly repeated on a smaller scale in each of the subdivisions of the larger branches up to 32 English feet high. All the branches were armed with sharp spines.

Palms, Yuccas, Aloes, tall-stemmed Ferns, some Aralias, and the Theophrasta where I have seen it growing luxuriantly, different as they are in the structure of their flowers, yet offer to the eye in the nakedness (absence of branches) of their stems, and in the ornamental character of their tops or crowns, a certain degree of physiognomic resemblance.

The Melanoselinum decipiens (Hofm.), which is sometimes upwards of 10 or 12 feet high, and which has been introduced into our gardens from Madeira, belongs to a peculiar group of arborescent umbelliferous plants to which Araliaceæ are otherwise allied, and with which other plants which will doubtless be discovered in course of time will be associated. Ferula, Heracleum, and Thapsia, do indeed attain a considerable height, but they are still herbaceous plants. Melanoselinum is still almost entirely alone as an umbelliferous tree; Bupleurum (Tenonia) fruticosum (Linn.) of the shores of the Mediterranean; Bubon galbanum of the Cape, and Crithmum maritimum of our sea-shores, are only shrubs. On the other hand, the tropical zone, in which, according to the old and very just remark of Adanson, Umbelliferæ and Cruciferæ are almost entirely wanting in the plains, presented to us on the high ridges of the American Andes the smallest and most dwarf-like of all umbelliferous plants. Among 38 species of plants which we collected at elevations where the mean temperature is below 10° Reaumur (54°.5 Fah.), there vegetate almost like mosses, and as if they made part of the rock and of the often frozen earth, at an elevation of 12600 (13430 English) feet above the level of the sea, Myrrhis andicola, Fragosa arctioïdes, and Pectophytum pedunculare, intermingled with which there is an equally dwarfed Alpine Draba. The only umbelliferous plants growing in the low grounds within the tropics observed by us in the New Continent were two species of Hydrocotyle (H. umbellata and H. leptostachya) between Havannah and Batabano; therefore at the extreme limits of the torrid Zone.

(27) p. 27.—"*The form of Gramineæ.*"

The group of arborescent grasses which Kunth, in his able treatise on the plants collected by Bonpland and myself, has combined under the name of Bambusaceæ, is among the most beautiful adornments of the tropical world. (Bambu, also called Mambu, is a word in the Malay language, but appears according to Buschmann to be of doubtful origin, as the usual Malay expression is buluh, in Java and Madagascar wuluh, voulu.) The number of genera and species which form this group has been extraordinarily augmented by the zeal of botanists. It is now recognised that the genus Bambusa is entirely wanting in the New Continent, to which on the other hand Guadua, from 50 to 60 French or about 53 to 64 English feet high, discovered by us, and Chusquea, exclusively belong; that Arundinaria (Rich) is common to both continents, although the species are different; that Bambusa and Beesha (Rheed.) are found in India and the Indian Archipelago, and Nastus in the Island of Bourbon, and in Madagascar. With the exception of the tall-climbing Chusquea the forms which have been named may be said to replace each other morphologically in the different parts of the world. In the northern hemisphere, in the valley of the Mississipi, the traveller is gratified, long before reaching the tropics, with the sight of a form of bamboo, the Arundinaria macrosperma, formerly called also Miegia, and Ludolfia. In the Southern Hemisphere Gay has discovered a Bambusacea, (a still undescribed species of Chusquea, 21 English feet high, which does not climb, but is arborescent and self-supporting) growing in southern Chili between the parallels of 37° and 42° S. latitude; where, intermixed with Drymis chilensis, a uniform forest covering of Fagus obliqua prevails.

While in India the Bambusa flowers so abundantly that in Mysore and Orissa the seeds are mixed with honey and eaten like rice, (Buchanan, Journey through Mysore, Vol. ii. p. 341, and Stirling in the Asiat Res. Vol. xv. p. 205) in South America the Guadua flowers so rarely, that in four years we were only twice able to procure blossoms; once on the unfrequented banks of the Cassiquiare, (the arm which connects the Orinoco with the Rio Negro and the Amazons River,) and once in the province of Popayan between Buga and Quilichao. It is striking to see plants in particular localities grow with the greatest vigour without producing flowers: it is thus with European olive trees which have been planted for centuries between the tropics near Quito, 9000 (about 9590 English) feet above the level of the sea, and also in the Isle of France with Walnut-trees, Hazel-nuts, and, as at Quito, olive trees (Olea europea): see Bojer, Hortus Mauritianus, 1837, p. 291.

As some of the Bambusaceæ (arborescent grasses) advance into the temperate zone, so within the tropics they do not suffer from the temperate climate of the mountains. They certainly grow more luxuriantly as social plants from the sea coast to the height of about 2560 English feet; for example, in the province de las Esmeraldas, west of the Volcano of Pichincha, where Guadua angustifolia (Bambusa Guadua in our Plantes équinoxiales, T. i. Tab. xx.) produces in its interior much of the siliceous Tabaschir (Sanscrit *tvakkschira*, ox-milk). In the pass of Quindiu we saw the Guadua growing at an elevation which we found by barometric measurement to be 5400 (5755 English) feet above the level of the Pacific. Nastus borbonicus is called by Bory de St. Vincent a true Alpine plant; he states that it does not descend lower on the declivity of the Volcano in the Island of Bourbon than 3600 (3837 English) feet. This recurrence or repetition as it were at great elevations of the forms characteristic of the hot plains, recalls the mountain group of palms before pointed out by me (Kunthia Montana, Ceroxylon andicola, and Oreodoxa frigida), and a grove or thicket of Musaceæ sixteen English feet high (Heliconia, perhaps Maranta), which I found growing isolated at an elevation of 6600 (7034 English) feet, on the Silla de Caraccas. (Rélation hist. T. i. p. 605-606.) As, with the exception of a few isolated herbaceous dicotyledones, grasses form the highest zone of phænogamous vegetation round the snowy summits of lofty mountains, so also, in advancing in a horizontal direction towards either pole of the Earth, the phænogamous vegetation terminates with grasses.

To my young friend Joseph Hooker, who, but just returned with Sir James Ross from the frozen antarctic regions, is now exploring the Thibetian portion of the Himalaya, the geography of plants is indebted not only for a great mass of important materials, but also for excellent general deductions. He calls attention to the circumstance that phænogamous flowering plants (grasses) approach 17½° nearer to the Northern than to the Southern pole. In the Falkland Islands near the thick masses of Tussack grass (Dactylis cæspitosa, Forster, according to Kunth a Festuca), and in Tierra del Fuego or Fuegia, under the shade of the birch-leaved Fagus antarctica, there grows the same Trisetum subspicatum which extends over the whole range of the Peruvian Cordilleras, and over the Rocky Mountains to Melville Island, Greenland, and Iceland, and which is also found in the Swiss and Tyrolese Alps, in the Altai mountains, in Kamtschatka, and in Campbell Island, south of New Zealand; therefore, from 54° South to 74½° North latitude, or through 128½° of latitude. "Few grasses," says Joseph Hooker, in his Flora Antarctica, p. 97, "have so wide a range as Trisetum subspicatum, (Beauv.) nor am I acquainted with any other Arctic species which is equally an inhabitant of the opposite polar regions." The South Shetland Islands, which are divided by Bransfield Strait from D'Urville's Terre de Louis Philippe and the Volcano of Haddington Peak, situated in 64° 12′ South latitude and 7046 English feet high, have been very recently visited by a Botanist from the United States of North America, Dr. Eights. He found there (probably in 62° or

62¼°, S. latitude) a small grass, Aira antarctica (Hooker, Icon. Plant. Vol. ii. Tab. 150) which is "the most antarctic flowering plant hitherto discovered."

In Deception Island, of the same group, S. lat. 62° 50′, lichens only are found, and not a single species of grass; and so also farther to the south-east, in Cockburn Island (lat. 64° 12′), near Palmer's Land, there were only found Lecanoras, Lecideas, and five Mosses, among which was our German Bryum argenteum: "this seems to be the ultima Thule of antarctic vegetation." Farther to the south, *land*-cryptogamic, as well as phænogamic, vegetation is entirely wanting. In the great bay formed by Victoria Land, on a small island which lies opposite to Mount Herschel (S. lat. 71° 49′), and in Franklin Island, 92 geographical miles North of the great volcano Mount Erebus, 12400 English feet high (latitude 76° 7′ South), Hooker found not a single trace of vegetable life. It is quite different in respect to the extension even of the forms of higher vegetable organisation in the high northern latitudes. Phænogamous plants there approach 18½° nearer to the pole than in the southern hemisphere: Walden Island (N. lat. 80½°) has still ten species. The antarctic phænogamous vegetation is also poorer in species at corresponding distances from the pole (Iceland has five times as many flowering plants as the southern group of Auckland and Campbell Islands), but this less varied antarctic vegetation is from climatic reasons more luxuriant and succulent. (Compare Hooker, Flora antarctica, p. vii., 74, and 215, with Sir James Ross, Voyage in the Southern and Antarctic Regions, 1839-1843, Vol. ii. p. 335-342.)

(28) p. 28.—"*Ferns.*"

If, with a naturalist deeply versed in the knowledge of the Agamæ, Dr. Klotzsch, we estimate the whole number of cryptogamic species hitherto described at 19000, this gives to Fungi 8000 (of which the Agarici constitute 1-8th); Lichens, according to J. von Flotow of Hirschberg, and Hampe of Blankenburg, at least 1400; Algæ 2580; Mosses and Liver-worts, according to Carl Müller of Halle, and Dr. Gottsche of Hamburgh, 3800; and Ferns 3250. We are indebted for this last important result to the thorough investigation of all that is known concerning this group of plants by Professor Kunze of Leipsic. It is remarkable that of the entire number of described Filices the family of Polypodiaceæ, alone, comprises 2165 species; while other forms, even Lycopodiaceæ and Hymenophyllaceæ, only count 350 and 200. There are, therefore, almost as many described ferns as described grasses.

It is remarkable that in the ancient classic writers, Theophrastus, Dioscorides, and Pliny, no notice occurs of the beautiful form of arborescent ferns; while from information derived from the companions of Alexander, Aristobulus, Megasthenes, and Nearchus, mention is made of Bamboos "quæ fissis internodiis lembi vice vectitabant navigantes;" of the Indian trees "quarum folia non minora clypeo sunt;" of the fig-tree of which the branches take root round the parent stem; and of Palms "tantæ proceritatis, ut sagittis superjici nequeant." (Humboldt, de Distributione geogr. Plantarum, p. 178 and 213.) I find the first description of tree-ferns in Oviedo's Historia de las Indias, 1535, fol. xc.

This experienced traveller, who had been placed by Ferdinand the Catholic as director of the gold-washings in Hayti, says: "Among the many ferns there are some which I reckon among trees, for they are as thick and as tall as pines (Helechos que yo cuento por arboles, tan gruesos como grandes pinos y muy altos). They grow chiefly in the mountains and where there is much water." The height is exaggerated. In the dense forests round Caripe even our Cyathea speciosa only attains a height of 30 to 35 (32 to 37 English) feet; and an excellent observer, Ernst Dieffenbach, in the northernmost of the three islands of New Zealand saw no stems of Cyathea dealbata of more than 40 (42½ English) feet in height. In the Cyathea speciosa and the Meniscium of the Chaymas missions we observed, in the midst of the shadiest primeval forest, in very luxuriantly growing individuals, the scaly stems covered with a shining carbonaceous powder. It seemed like a singular decomposition of the fibrous parts of the old frond stalks. (Humboldt, Rel. hist. T. i. p. 437.)

Between the tropics, where, on the declivities of the Cordilleras, climates are placed successively in stages one above another, the proper zone of the tree-ferns is between three and five thousand feet (about 3200 and 5330 English) above the level of the sea. In South America and in the Mexican highlands they seldom descend lower towards the plains than 1200 (about 1280 Eng.) feet. The mean temperature of this happy zone falls between 17° and 14°.5 Reaumur (70°.2 and 64°.6 Fahr.) This region enters the lowest stratum of clouds, or that which floats next above the sea and the plains; and hence, besides great equality of temperature, it also enjoys uninterruptedly a high degree of humidity. (Robert Brown, in Appendix to Expedition to Congo, p. 423.) The inhabitants, who are of Spanish descent, call this zone "tierra templada de los helechos." The Arabic word for fern is *feledschun*, *f* being changed into *h* in helechos according to Spanish custom: perhaps the Arabic feledschun is connected with "faladscha," "it divides;" in allusion to the finely divided margins of fern leaves or fronds. (Abu Zacaria Ebn el Awam, Libro de Agricultura, traducido por J. A. Banqueri, T. ii. Madr. 1802, p. 736.)

The conditions of mild temperature and an atmosphere nearly saturated with vapour, together with great equability of climate in respect to both temperature and moisture, are fulfilled on the declivities of the mountains, in the valleys of the Andes, and above all in the mild and humid atmosphere of the southern hemisphere, where arborescent ferns extend not only to New Zealand and Van Diemen Island (Tasmania), but even to the Straits of Magellan and to Campbell Islands, or to a latitude almost corresponding to that of Berlin in the northern hemisphere. Of tree-ferns, Dicksonia squarrosa grows vigorously in 46° South latitude, in Dusky Bay (New Zealand); D. antarctica of Labillardière in Tasmania; a Thyrsopteris in Juan Fernandez; an undescribed Dicksonia with stems from 12 to 15 (nearly 13 to 16 English) feet in the south of Chili, not far from Valdivia; and a Lomaria of rather less height in the Straits of Magellan. Campbell Island is still nearer to the south pole, in 52½° lat., and even there the stem of the Aspidium venustum rises to

4 feet (4 feet 3 inches, English) before the fronds branch off.

The climatic relations under which Ferns in general flourish, are manifested in the numerical laws of their quotients of distribution taken in the manner alluded to in an earlier part of the present volume. In the low plains of the great continents within the tropics, the quotient for ferns is, according to Robert Brown, and according to late researches, 1-20th of all the species of phænogamous plants growing in the same region; in the mountainous parts of the great continents in the same latitudes it is from 1-8th to 1-6th. But a very different ratio is found in the small islands dispersed over the wide ocean. The proportion of ferns to the whole number of Phanerogamæ increases there in such a manner that in the groups of islands between the tropics in the Pacific the ferns equal a fourth,—and in the solitary far detached islands in the Atlantic Ocean, St. Helena, and Ascension,—almost equal the half of the entire phænogamous vegetation. (See an excellent memoir of D'Urville entitled Distribution géographique des Fougères sur la surface du Globe, in the Annales des Sciences Nat. T. vi. 1825, p. 51, 66, and 73). From the tropics (where in the great continents D'Urville estimates the ratio generally at 1 : 20) we see the relative frequency of ferns decrease rapidly in the temperate zone. The quotients are: for North America and for the British Islands $\frac{1}{35}$, for France $\frac{1}{58}$, for Germany $\frac{1}{52}$, for the dry parts of the south of Italy $\frac{1}{74}$, and for Greece $\frac{1}{84}$. Towards the colder regions of the north we see the *relative* frequency increase again rapidly; that is to say, the number of species of ferns decreases much more slowly than does the number of species of phænogamous plants. At the same time, the luxuriance, abundance, and mass of individuals in each species augments the illusive impression of *absolute* numbers. According to Wahlenberg's and Hornemann's Catalogues the relative numbers of Filices are, for Lapland $\frac{1}{25}$, for Iceland $\frac{1}{18}$, and for Greenland $\frac{1}{12}$.

Such, according to the present state of our knowledge, are the natural laws manifested in the distribution of the pleasing form of Ferns. But it would seem as if in the family of Ferns, which has so long been regarded as a cryptogamic family, we had quite recently arrived on the traces of another natural law, a morphological one of propagation. Count Leszczyc-Suminski, who happily unites the gift of microscopic examination with distinguished artistic talent, has discovered in the prothallium of ferns an organisation by which fructification is effected. He distinguishes a bisexual arrangement in the ovule-like cell on the middle of the theca, and in the ciliated antheridia or spiral threads before examined by Nägeli. The fertilisation is supposed to take place not by pollen tubes but by the moveable ciliated spiral threads. (Suminski zur Entwickelungs-geschichte der Farrnkräuter, 1848, S. 10-14.) According to this view, Ferns, as Ehrenberg expresses it (Monatl. Berichte der Akad. zu Berlin, Januar 1848, S. 20), would be produced by a microscopic fertilisation taking place on the prothallium as a receptacle; and throughout the whole remainder of their often arborescent development they would be flowerless and fruitless plants, forming buds or bulbs; the spores or sori on the under side of the frond not being seeds but flower buds.

(29) p. 28.—"*Liliaceæ.*"

The principal seat of this form is Africa, where it is both most varied and most abundant, and where these beautifully flowering plants are assembled in masses and determine the aspect and character of the country. The New Continent does, indeed, also possess superb Alstromeriæ and species of Pancratium, Hæmanthus, and Crinum (we augmented the first-named of these genera by nine, and the second by three species); but these American Liliaceæ grow dispersed, and are less social than our European Irideæ.

(30) p. 28.—"*Willow Form.*"

Of the leading representative of this form, the Willow itself, 150 different species are already known. They are spread over the northern hemisphere from the Equator to Lapland. They appear to increase in number and diversity of form between the 46th and 70th degrees of north latitude, and especially in the part of north of Europe where the configuration of the land has been so strikingly indented by early geological changes. Of Willows as tropical plants I am acquainted with ten or twelve species, which, like the willows of the southern hemisphere, are deserving of particular attention. As Nature seems as it were to take pleasure in multiplying certain forms of animals, for example Anatidæ (Lamellirostres) and Columbæ, in all the zones of the earth;

so are Willows, the different species of Pines, and Oaks, no less widely disseminated: the latter (oaks) being always alike in their fruit, though much diversified in the forms of their leaves. In Willows, the similarity of the foliage, of the ramification, and of the whole physiognomic appearance, in the most different climates, is unusually great,—almost greater than even in Coniferæ. In the southern part of the temperate zone of the northern hemisphere the number of species of willows decreases considerably, yet (according to the Flora atlantica of Desfontaines) Tunis has still a species of its own resembling Salix caprea; and Egypt reckons, according to Forskäl, five species, from the catkins of whose male flowers a medicine much employed in the East, Moie chalaf (aqua salicis) is obtained by distillation. The Willow which I saw in the Canaries is also, according to Leopold von Buch and Christian Smith, a peculiar species, common however to that group and to the Island of Madeira,—S. canariensis. Wallich's Catalogue of the plants of Nepaul and of the Himalaya cites from the Indian sub-tropical zone thirteen species, partly described by Don, Roxburgh, and Lindley. Japan has its indigenous willows, one of which, S. japonica (Thunb.) is also found as a mountain plant in Nepaul.

Previous to my expedition, the Indian Salix tetrasperma was the only known intertropical species, so far as I am aware. We collected seven new species, three of which were from the elevated plains of Mexico, and were found to extend to an elevation of 8000 (about 8500 English) feet above the level of the sea. At still greater elevations,—for example, on the mountain plains situated between 12000 and 14000 feet, (about 12790 and 14920 English,) which we often visited,—we did not find, either in the Andes of Mexico or in those of Quito and Peru, any thing which could recall the small creeping alpine willows of the Pyrenees, the Alps, and Lapland (S. herbacea, S. lanata, and S. reticulata). In Spitzbergen, where the meteorological conditions have much analogy with those of the Swiss and Scandinavian snow-mountains, Martins described two dwarf willows, of which the small woody stems and branches creep on the ground, and which lie so concealed in the turf-bogs that their small leaves are only discovered with difficulty under the moss. The species found by me in Peru in 4° 12′ S. latitude, near Loxa, at the entrance of the forests where the best Cinchona bark is collected, and described by Willdenow as Salix humboldtiana, is the one which is most widely distributed in the western part of South America. A sea-shore species, S. falcata, which we found on the sandy coast of the Pacific, near Truxillo, is, according to Kunth, probably only a variety of the above; and possibly the fine and often pyramidal willow which accompanied us along the banks of the Magdalena, from Mahates to Bojorque, and which, according to the report of the natives, had only extended so far within a few years, may also be identical with Salix humboldtiana. At the confluence of the Rio Opon with the Magdalena, we found all the islands covered with willows, many of which had stems 64 English feet high, but only 8 to 10 inches in diameter. (Humboldt and Kunth, Nova Gen. Plant. T. ii. p. 22, tab. 99.) Lindley has made us acquainted with a species of Salix from Senegal, and therefore in the African equinoctial zone. (Lindley, Introduction to the Natural System of Botany, p. 99.) Blume also found two species of Salix near the equator, in Java: one wild and indigenous, S. tetrasperma; and another cultivated, S. sieboldiana. From the southern temperate zone I know only two willows described by Thunberg, (S. hirsuta and S. mucronata); they grow by the side of Protea argentea (which has itself very much the physiognomy of a willow), on the banks of the Orange River, and their leaves and young shoots form the food of the hippopotamus. Willows are entirely wanting in Australia and the neighbouring islands.

(31) p. 29.—"*Myrtaceæ.*"

An elegant form, with stiff, shining, thickly set, generally unindented, small leaves, studded with pellucid dots. Myrtaceæ give a peculiar character to three districts of the earth's surface,—the South of Europe, particularly the calcareous and trachytic islands which rise above the surface of the Mediterranean;—the continent of New Holland, adorned with Eucalyptus, Metrosideros, and Leptospermum;—and an intertropical region, part of which is low, and part from nine to ten thousand feet high (about 9590 to 10660 English), in the Andes of South America. This mountain district, called in Quito the district of the Paramos, is entirely covered with trees which have a myrtle-like aspect and character, even though they may not all belong to the natural family of Myrtaceæ. Here, at the above-named elevation, grow the Escallonia myrtilloides,

E. tubar, Simplocos alstonia, some species of Myrica, and the beautiful Myrtus microphylla which we have figured in the Plantes équinoxiales, T. i. p. 21, Pl. iv. We found it growing on mica slate, and extending to an elevation of more than ten thousand English feet, on the Paramo de Saraguru, near Vinayacu and Alto de Pulla, which is adorned with so many lovely alpine flowering plants. Myrtus myrsinoides even extends in the Paramo de Guamani up to 10500 (11190 English) feet. Of the 40 species of the Genus Myrtus which we collected in the equinoctial zone, and of which 37 were undescribed, much the greater part belonged, however, to the plains and lower mountains. From the mild tropical mountain climate of Mexico we brought back only a single species (Myrtus xalapensis); but the Tierra templada, towards the Volcano of Orizaba, must no doubt contain several more. We found M. maritima near Acapulco, quite on the sea-coast of the Pacific.

The Escallonias,—among which E. myrtilloides, E. tubar, and E. floribunda, are the ornament of the Paramos, and by their physiognomy remind the beholder strongly of the myrtle-form,—once constituted, in combination with the European and South American Alp-roses (Rhododendrum and Befaria), and with Clethra, Andromeda, and Gaylussacia buxifolia, the family of Ericeæ. Robert Brown (see the Appendix to Franklin's Narrative of a Journey to the Shores of the Polar Sea, 1823, p. 765), has raised them to the rank of a separate family, which Kunth places between Philadelpheæ and Hamamelideæ.

The Escallonia floribunda offers in its geographical distribution one of the most striking examples, in the habitat of the plant, of proportion between distance from the equator and vertical elevation above the level of the sea. In making this statement I again support myself on the authority of my acute and judicious friend Auguste de St.-Hilaire (Morphologie végétale, 1840, p. 52):—"Messieurs de Humboldt et Bonpland ont découvert dans leur expédition l'Escallonia floribunda à 1400 toises par les 4° de latitude australe. Je l'ai retrouvé par les 21° au Brésil dans un pays élevé, mais pourtant infiniment plus bas que les Andes du Pérou: il est commun entre les 24°.50′ et les 25°.55′ dans les Campos Geræs, enfin je le revois au Rio de la Plata vers les 35°, au niveau même l'océan."

Trees belonging the group of Myrtaceæ,—to which Melaleuca, Metrosideros, and Eucalyptus belong in the sub-division of Leptospermeæ,—produce partially, either where the leaves are replaced by phyllodias (leaf-stalk leaves), or by the peculiar disposition or direction of the leaves relatively to the unswollen leaf-stalk, a distribution of stripes of light and shade unknown in our forests of round-leaved trees. The first botanical travellers who visited New Holland were struck with the singularity of the effect thus produced. Robert Brown was the first to show that this strange appearance arose from the leaf-stalks (the phyllodias of the Acacia longifolia and A. suaveolens) being expanded in a vertical direction, and from the circumstance that the light instead of falling on horizontal surfaces, falls on and passes between vertical ones. (Adrien de Jussieu, Cours de

Botanique, p. 106, 120, and 700; Darwin, Journal of Researches, 1845, p. 433). Morphological laws in the development of the leafy organs determine the peculiar character of the effects produced, the outlines of light and shade. "Phyllodias," says Kunth, "can, according to my view, only occur in families which have compound pinnated leaves; and in point of fact they have as yet only been found in Leguminosæ, (in Acacias). In Eucalyptus, Metrosideros, and Melaleuca, the leaves are simple (simplicia), and their edgewise position arises from a half turn or twist of the leaf-stalk (petiolus); it should be remarked at the same time that the two surfaces of the leaves are similar." In the comparatively shadeless forests of New Holland the optical effects here alluded to are the more frequent, as two groups of Myrtaceæ and Leguminosæ, species of Eucalyptus and of Acacia, constitute almost the half of all the greyish green trees of which those forests consist. In addition to this, in Melaleuca there are formed between the layers of the inner bark easily detached portions of epidermis which press outwards, and by their whiteness remind the European of our birch bark.

The distribution of Myrtaceæ is very different in the two continents. In the New Continent, and especially in its western portion, it scarcely extends beyond the 26th parallel of north latitude, according to Joseph Hooker (Flora antarctica, p. 12); while in the Southern Hemisphere, according to Claude Gay, there are in Chili 10 species of Myrtus and 22 species of Eugenia, which, intermixed with Proteaceæ (Embothrium and Lomatia), and with Fagus obliqua, form forests. The Myrtaceæ become more abundant beyond 38° S. lat.,—in the Island of Chiloe, where a Metrosideros-like species of Myrtus (Myrtus stipularis) forms almost impenetrable thickets under the name of Tepuales; in Patagonia; and in Fuegia to its extremity in 56½° S. lat. In the Old Continent they prevail in Europe as far as the 46th parallel of North latitude: in Australia, Tasmania, New Zealand, and the Auckland Islands, they advance to 50½° South latitude.

(32) p. 29.—"*Melastomaceæ.*"

This group comprises the genera Melastoma (Fothergilla and Tococa Aubl.) and Rhexia (Meriana and Osbeckia), of which we found, on either side of the equator in tropical America alone, 60 new species. Bonpland has published a superb work on Melastomaceæ, in two volumes, with coloured drawings. Some species of Rhexia and Melastoma ascend in the Andes, as alpine or Paramos shrubs, as high as nine and ten thousand five hundred (about 9600 and 11190 English) feet: among these are Rhexia cernua, R. stricta, Melastoma obscurum, M. aspergillare, and M. lutescens.

(33) p. 29.—"*Laurel-form.*"

To this form belong the genera of Laurus and Persea, the Ocoteæ so numerous in South America, and (on account of physiognomic resemblance), Calophyllum and the superb aspiring Mammea, from among the Guttiferæ.

(34) p. 29.—"*How interesting and instructive to the landscape painter would be a work which should present to the eye the leading forms of vegetation!*"

In order to define somewhat more distinctly what is here only briefly alluded to, I permit myself to introduce some considerations taken from a sketch of the history of landscape painting, and of a graphical representation of the physiognomy of plants, which I have given in the second volume of Kosmos (Bd. ii. S. 88-90; English edit. vol. ii. p. 86-87).

"All that belongs to the expression of human emotion and to the beauty of the human form, has attained perhaps its highest perfection in the northern temperate zone, under the skies of Italy and Greece. By the combined exercise of imitative art and of creative imagination, the artist has derived the types of historical painting at once from the depths of his own mind, and from the contemplation of other beings of his own race. Landscape painting, though no merely imitative art, has, it may be said, a more material substratum and a more terrestrial domain: it requires a greater mass and variety of distinct impressions, which the mind must receive within itself, fertilize by its own powers, and reproduce visibly as a free work of art. Hence landscape painting must be a result at once of a deep and comprehensive reception of the visible spectacle of external nature, and of this inward process of the mind."

"Nature, in every region of the earth, is indeed a reflex of the whole; the forms of organised beings are repeated everywhere in fresh combinations; even in the icy north, herbs covering the earth, large alpine blossoms, and a serene azure sky, cheer a portion of the year. Hitherto landscape painting has pursued amongst us her pleasing task, familiar only with the simpler form of our native floras, but not, therefore, without depth of feeling, or without the treasures of creative imagination. Even in this narrower field, highly gifted painters, the Caracci, Gaspar Poussin, Claude Lorraine, and Ruysdael, have with magic power, by the selection of forms of trees and by effects of light, found scope wherein to call forth some of the most varied and beautiful productions of creative art. The fame of these master-works can never be impaired by those which I venture to hope for hereafter, and to which I could not but point, in order to recall the ancient but deeply-seated bond which unites natural knowledge with poetry and with artistic feeling; for we must ever distinguish in landscape painting, as in every other branch of art, between productions derived from direct observation, and those which spring from the depths of inward feeling and from the power of the idealising mind. The great and beautiful works which owe their origin to this creative power of the mind applied to landscape-painting, belong to the poetry of nature, and like man himself, and the imagination with which he is gifted, are not rivetted to the soil, or confined to any single region. I allude here more particularly to the gradation in the form of trees from Ruysdael and Everdingen, through Claude Lorraine to Poussin and Annibal Caracci. In the great masters of the art we perceive no trace of local limitation; but an enlargement of the visible horizon, and an increased acquaintance with the nobler and grander forms of nature, and with the luxuriant fulness of life in the tropical world, offer the advantage not only of enriching the material substratum of landscape painting, but also of affording a more lively stimulus to less gifted artists, and of thus heightening their powers of production."

(35) p. 30.—"*From the rough bark of Crescentias and Gustavia.*"

In the Crescentia cujete (the Tutuma or Calabash-tree, whose large fruit-shells are so useful to the natives for household purposes),—in the Cynometra, the Theobroma (the Cacao-tree), and the Perigara (the Gustavia of Linnæus),—the delicate flowers break through the half carbonized bark. When children eat the fruit of the Pirigara speciosa (the Chupo), their whole body becomes tinged with yellow; it is a jaundice, which lasts from 24 to 36 hours, and then disappears without the use of medicine.

I have never forgotten the impression which I received of the luxuriant power of vegetation in the tropical world, when on entering a Cacao plantation (Caca hual), in the Valles de Aragua, after a damp night, I saw for the first time large blossoms springing from a root of the Theobroma deeply imbedded in black earth. It was one of the most instantaneous manifestations of the activity of the vegetative organic forces. Northern nations speak of the "awakening of Nature at the first breath of the mild air of spring." Such an expression is singularly contrasted with the imagination of the Stagirite, who recognised in plants forms which "lie buried in a tranquil slumber that knows no waking, free from the desires which impel to spontaneous motion." (Aristot. de generat. Animal. V. i. p. 778, and de somno et vigil. cap. 1, p. 455, Bekker.)

(36) p. 30.—"*Draw over their heads.*"

The flowers of our Aristolochia cordata, to which I have already referred in Note 25. The largest flowers in the world, apart from Compositæ (in the Mexican Helianthus annuus), belong to Rafflesia arnoldi, Aristolochia, Datura, Barringtonia, Gustavia, Carolinea, Lecythis, Nymphæa, Nelumbium, Victoria regina, Magnolia, Cactus, and to Orchideous and Liliaceous plants.

(37) p. 31.—"*To behold all the shining worlds which stud the heavenly vault from pole to pole.*"

The finest portion of the southern celestial hemisphere, where shine the constellations of the Centaur, the Ship, and the southern Cross, and where the soft lustre of the Magellanic clouds is seen, remains for ever concealed from the view of the inhabitants of Europe. It is only beneath the equinoctial line that Man enjoys the peculiar privilege of beholding at once all the stars both of the Southern and the Northern heavens. Some of our northern constellations seen from thence appear from their low altitude of a surprising and almost awful magnitude: for example, Ursus major and minor. As the inhabitant of the tropics sees all the stars of the firmament, so also, in regions where plains alternate with deep valleys and lofty mountains, Nature surrounds him with representatives of all the forms of plants.

POSTSCRIPT

ON THE

PHYSIOGNOMIC CLASSIFICATION OF PLANTS.

In the preceding sketch of a "Physiognomy of Plants," I have had principally in view three nearly allied subjects :—the absolute diversity of forms; their numerical proportion, *i. e.* their local predominance in the total number of species in phænogamous floras; and their geographic and climatic distribution. If we desire to rise to general views respecting organic forms, the physiognomy of plants, the study of their numerical proportions (or the arithmetic of botany),—and their geography (or the study of their zones of distribution),—cannot, as it appears to me, be separated from each other. In the study of the physiognomy of plants, we ought not to dwell exclusively on the striking contrasts presented by the larger organic forms separately considered, but we should also seek to discern the laws which determine the physiognomy of Nature generally, or the picturesque character of vegetation over the entire surface of the globe, and the impression produced on the mind of the beholder by the grouping of contrasted forms in different zones of latitude and of elevation. It is from this point of view, and with this concentration or combination of objects, that we become aware, for the first time, of the close and intimate connection between the subjects which have been treated of in the foregoing pages. We are here conducted into a field which has been as yet but little cultivated. I have ventured to follow the method first employed with such brilliant results in the Zoological works of Aristotle, and which is especially suited to lay the foundation of scientific confidence,—a method which, whilst it continually aims at generality of conception, seeks, at the same time, to penetrate the specialities of phenomena by the consideration of particular instances.

The enumeration of forms according to physiognomic diversity is, from the nature of the case, not susceptible of any strict classification. Here, as everywhere else, in the consideration of external conformation, there are certain leading forms which present the most striking contrasts: such are the groups of arborescent grasses, plants of the aloë form, the different species of cactus, palms, needle-trees, Mimosaceæ, and Musaceæ. Even a few scattered individuals of these groups are sufficient to determine the character of a district, and to produce on a non-scientific but sensitive beholder a permanent impression. Other forms, though perhaps much more numerous and preponderating in mass, may not be calculated either by the outline and arrangement of the foliage, or by the relation of the stem to the branches,—by luxuriant vigour of vegetation,—by cheerful grace,—or, on the other hand, by cheerless contraction of the appendicular organs, to produce any such characteristic impressions.

As, therefore, a "physiognomic classification," or a division into groups from external aspect or "facies," does not admit of being applied to the whole vegetable kingdom, so also, in such a classification, the grounds on which the division is made are quite different from those on which our systems of natural families and of plants (including the whole of the vegetable kingdom) have been so happily established. Physiognomic classification grounds her divisions and the choice of her types on whatever possesses "mass," — such as shape, position and arrangement of leaves, their size, and the character and surfaces (shining or dull) of the parenchyma,—therefore, on all that are called more especially the "organs of vegetation," *i. e.* those on which the preservation,—the nourishment and development,—of the individual depend; while systematic Botany, on the other hand, grounds the arrangement of natural families on the consideration of the organs of propagation,—those on which the continuation or preservation of the species depends. (Kunth, Lehrbuch der Botanik, 1847, Th. i. S. 511; Schleiden, die Pflanze und ihr Leben, 1848, S. 100). It was already taught in the school of Aristotle (Probl. 20, 7), that the production of seed is the ultimate object of the existence and life of the plant. Since Caspar Fried. Wolf (Theoria Generationis, § 5-9), and since our great (German) Poet, the process of development in the organs of fructification has become the morphological foundation of all systematic botany.

That study, and the study of the physiognomy of plants, I here repeat, proceed from two different points of view: the first from agreement in the inflorescence or in the delicate organs of reproduction; the second from the form of the parts which constitute the axes (*i. e.* the stems and branches), and the shape of the leaves, dependent principally on the distribution of the vascular fascicles. As, then, the axes and appendicular organs predominate by their volume and mass, they determine and strengthen the impression which we receive; they individualise the physiognomic character of the vegetable form and that of the landscape, or of the region in which any of the more strongly-marked and distinguished types severally occur. The law is here given by agreement and affinity in the marks taken from the vegetative, *i. e.* the nutritive organs. In all European colonies, the inhabitants have taken occasion, from resemblances of physiognomy (of "habitus," "facies"), to bestow the names of European forms upon tropical plants or trees bearing very different flowers and fruits from those from which the names were originally taken. Everywhere, in both hemispheres, northern settlers have thought they found Alders, Poplars, Apple- and Olive-trees. They have been misled in most cases by the form of the leaves and the direction of the branches. The illusion has been favoured by the cherished remembrance of the trees and plants of home, and thus European names have been handed down from generation to generation; and in the slave colonies there have been added to them denominations derived from Negro languages.

The contrast so often presented between a striking agreement of physiognomy and the greatest diversity in the inflorescence and fructification,—between the external aspect as determined by the appendicular or leaf-system, and the reproductive organs on which the groups of the natural systems of botany are founded,—is a remarkable and surprising phenomenon. We should have been inclined beforehand to imagine that the shape of what are exclusively termed the vegetative organs (for example, the leaves) would have been less *independent* of the structure of the organs of reproduction; but in reality such a dependence only shows itself in a small number of families,—in Ferns, Grasses and Cyperaceæ, Palms, Coniferæ, Umbelliferæ, and Aroideæ. In Leguminosæ the agreement in physiognomic character is scarcely to be recognised until we divide them into the several groups (Papilionaceæ, Cæsalpinineæ, and Mimoseæ). I may name, of types which, when compared with each other, shew considerable accordance in physiognomy with great difference in the structure of the flowers and fruit, Palms and Cycadeæ, the latter being more nearly allied to Coniferæ; Cuscuta, one of the Convolvulaceæ, and the leafless Cassytha, a parasitical Laurinea; Equisetum (belonging to the great division of Cryptogamia), and Ephedra, closely allied to Coniferæ. On the other hand, our common gooseberries and currants (Ribes) are so closely allied by their inflorescence to the Cactus, *i. e.* to the family of Opuntiaceæ, that it is only quite recently that they have been separated from it! One and the same family (that of Asphodeleæ) comprises the gigantic Dracæna draco, the common asparagus, and the Aletris with its coloured flowers. Not only do simple and compound leaves often belong to the same family, but they even occur in the same genus. We found in the high plains of Peru and New Granada, among twelve new species of Weinmannia, five with "foliis simplicibus," and the rest with pinnate leaves. The genus Aralia shews still greater independence in the form of the leaves: "folia simplicia, integra, vel lobata, digitata et pinnata." (Compare Kunth, Synopsis Plantarum quas in itinere collegerunt, Al. de Humboldt et Am. Bonpland, T. iii, p. 87 and 360.)

Pinnated leaves appear to me to belong chiefly to families which are in the highest grade of organic devolopment, namely, the Polypetalæ; and among these, in the Perigynic class, to the Leguminosæ, Rosaceæ, Terebinthaceæ, and Juglandeæ; and in the Hypogynic, to the Aurantiaceæ, Cedrelaceæ, and Sapindaceæ. The beautiful doubly-pinnated leaves which form one of the principal ornaments of the torrid zone, are most frequent among the Leguminosæ, in Mimoseæ, also in some Cæsalpinieæ, Coulterias, and Gleditschias; never, as Kunth remarks, in Papilionaceæ. "Folia pinnata" and "folia composita" are never found in Gentianeæ, Rubiaceæ, and Myrtaceæ. In the morphological development presented by the abundance and variety of form in the appendicular organs of Dicotyledones, we can at present discern only a small number of general laws.

ON THE
STRUCTURE AND MODE OF ACTION
OF
VOLCANOS,
IN DIFFERENT PARTS OF THE GLOBE.

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WHEN we reflect on the influence which, for some centuries past, the progress of geography and the multiplication of distant voyages and travels have exercised on the study of nature, we are not long in perceiving how different this influence has been, according as the researches were directed to organic forms on the one hand, or on the other to the study of the inanimate substances of which the earth is composed—to the knowledge of rocks, their relative ages, and their origin. Different forms of plants and animals enliven the surface of the earth in every zone, whether the temperature of the atmosphere varies in accordance with the latitude and with the many inflections of the isothermal lines on plains but little raised above the level of the sea, or whether it changes rapidly in ascending in an almost vertical direction the steep declivities of mountain-chains. Organic nature gives to each zone of the earth a peculiar physiognomy; but where the solid crust of the earth appears unclothed by vegetation, inorganic nature imparts no such distinctive character. The same kinds of rocks, associated in groups, appear in either hemisphere, from the equator to the poles. In a remote island, surrounded by exotic vegetation, beneath a sky where his accustomed stars no longer shine, the voyager often recognises with joy the argillaceous schists of his birth-place, and the rocks familiar to his eye in his native land.

This absence of any dependence of geological relations on the present constitution of climates does not preclude or even diminish the salutary influence of numerous observations made in distant regions on the advance and progress of geological science, though it imparts to this progress something of a peculiar direction. Every expedition enriches natural history with new species or new genera of plants and animals: there are thus presented to us sometimes forms which connect themselves with previously long known types, and thus permit us to trace and contemplate in its perfection the really regular though apparently broken or interrupted network of organic forms: at other times shapes which appear isolated,—either surviving remnants of extinct genera or orders, or otherwise members of still undiscovered groups, stimulating afresh the spirit of research and expectation. The examination of the solid crust of the globe does not, indeed, unfold to us such diversity and variety; it presents to us, on the contrary, an agreement in the constituent particles, in the superposition of the different kinds of masses, and in their regular recurrence, which excites the admiration of the geologist. In the chain of the Andes, as in the mountains of middle Europe, one formation appears, as it were, to summon to itself another. Rocks of the same name exhibit the same outlines; basalt and dolerite form twin mountains; dolomite, sandstone, and porphyry, abrupt precipices; and vitreous feldspathic trachyte, high dome-like elevations. In the most distant zones large crystals separate themselves in a similar manner from the compact texture of the primitive mass, as if by an internal development, form groups in association, and appear associated in layers, often announcing the vicinity of new independent formations. Thus in any single system of mountains of considerable extent we see the whole inorganic substances of which the crust of the earth is composed represented, as it were, with more or less distinctness; yet, in order to become completely acquainted with the important phenomena of the composition, the relative age, and mode of origin of rocks, we must compare together observations from the most varied and remote regions. Problems which long perplexed the geologist in his native land in these northern countries, find their solution near the equator. If, as has been already remarked, new zones do not necessarily present to us new kinds of rock (*i. e.* unknown groupings or associations of simple substances), they, on the other hand, teach us to discern the great and every where equally prevailing laws, according to which the strata of the crust of the earth are superposed upon each other, penetrate each other as veins or dykes, or are upheaved or elevated by elastic forces.

If, then, our geological knowledge is thus promoted by researches embracing extensive parts of the earth's surface, it is not surprising that the particular class of phenomena which form the subject of the present discussion should long have been regarded from a point of view the more restricted as the points of comparison were of difficult, I might almost say arduous and painful, attainment and access. Until the close of the last century all real or supposed knowledge of the structure or form of volcanos, and of the mode of operation of subterranean forces, was taken from two mountains of the South of Europe, Vesuvius and Etna. The former of these being the easiest of access, and its eruptions, as is generally the case in volcanos of small elevation, being most frequent in their occurrence, a hill of minor elevation became the type which regulated all the ideas formed respecting phænomena exhibited on a far larger scale in many vast and distant regions, as in the mighty volcanos arranged in linear series in Mexico, South America, and the Asiatic Islands. Such a proceeding might not unnaturally recall Virgil's shepherd, who thought he beheld in his humble cottage the type of the eternal City, Imperial Rome.

A more careful examination of the whole of the Mediterranean, and especially of those islands and coasts where men awoke to the noblest intellectual culture, might, however, have dispelled views formed from so limited a consideration of nature. Among the Sporades, trachytic rocks have been upraised from the deep bottom of the sea, forming islands resembling that which, in the vicinity of the Azores, appeared thrice periodically, at nearly equal intervals, in three centuries. The Peloponnesus has, between Epidaurus and Trœzene, near Methone, a Monte Nuovo described by Strabo and seen again by Dodwell, which is higher than the Monte Nuovo of the Phlegræan Fields near Baiæ, and perhaps even higher than the new volcano of Jorullo in the plains of Mexico, which I found surrounded by several thousand small basaltic cones which had been protruded from the earth and were still smoking. In the Mediterranean and its shores, it is not only from the permanent craters of isolated mountains having a constant communication with the interior, as Stromboli, Vesuvius, and Etna, that volcanic fires break forth: at Ischia, on the Monte Epomeo, and also, as it would appear by the accounts of the ancients, in the Lelantine plain near Chalcis, lavas have flowed from fissures which have suddenly opened at the surface of the earth. Besides these phænomena, which fall within the historic period, or within the restricted domain of well-assured tradition, and which Carl Ritter will collect and elucidate in his masterly work on Geography,—the shores of the Mediterranean exhibit numerous remains of more ancient volcanic action. In the south part of France, in Auvergne, we see a separate complete system of volcanos arranged in lines, trachytic domes alternating with cones of eruption, from which streams of lava have flowed in narrow bands. The plain of Lombardy, as level as the surface of the sea, and forming an inner Gulf of the Adriatic, surrounds the trachyte of the Euganean Hills, where rise domes of granular trachyte, obsidian, and pearl-stone, masses connected by a common origin, which break through the lower cretaceous rock and nummulitic lime-stone, but have never flowed in narrow streams. Similar evidences of ancient revolutions of nature are found in several parts of the mainland of Greece and in Asia Minor, countries which will one day offer a rich field for geological investigation, when intellectual light shall revisit the seats from which it has radiated to the western world, and when oppressed humanity shall no longer be subject to the barbarism of Turkish rule.

I recall the geographical proximity of these various phænomena, in order to shew that the basin of the Mediterranean, with its series of islands, might have offered to an attentive observer much that has been recently discovered, under various forms, in South America, Teneriffe, and the Aleutian Islands near the polar circle. The objects to be observed were assembled within a moderate distance; yet distant voyages, and the comparison of extensive regions in and out of Europe, have been required for the clear perception and recognition of the resemblance between volcanic phænomena and their dependence on each other.

Our ordinary language, which often gives permanency and apparent authority to the first-formed erroneous views of natural phænomena, but which also often points instinctively to the truth,—our ordinary language, I repeat, applies the term "volcanic" to all eruptions of subterranean fires or molten substances; to columns of smoke and vapour rising from rocks, as at Colares after the great earthquake of Lisbon;

to "Salses" or mud volcanos, argillaceous cones emitting mud, asphalte, and hydrogen, as at Girgenti in Sicily, and at Turbaco in South America; to the Geysers, hot springs in which, as in those of Iceland, the waters, pressed by elastic vapours, rise in jets to a considerable altitude; and, in general, to all operations of natural forces having their seat in the interior of our planet. In Central America (Guatimala), and in the Philippine Islands, the natives even distinguish formally between water- and fire-volcanos, Volcanes de agua y de fuego, giving the former name to those mountains from which subterranean waters issue from time to time with violent earthquake shocks and a hollow noise.

Not denying the connexion of the different phenomena which have been referred to, it yet appears desirable to give greater precision to the terms employed in the physical as well as in the mineralogical part of geology, and not to apply the word "volcano" at one moment to a mountain terminating in a permanent igneous opening or fiery crater, and at another to every subterranean cause of volcanic phenomena. In the present state of our planet the most ordinary form of volcanos is indeed in all parts of the globe that of an isolated conical mountain, such as Vesuvius, Etna, the Peak of Teneriffe, Tunguragua, and Cotapaxi. I have myself seen such volcanos varying in size from the smallest hill to an elevation of 18000 (19184 English) feet above the sea. But besides these isolated cones there are also permanent openings or craters, having established channels of communication with the interior of the earth, which are situated on long chains of mountains with serrated crests, and not even always on the middle of the ridge, but sometimes at its extremity: such is Pichincha, situated between the Pacific and the city of Quito, and which acquired celebrity in connection with Bouguer's earliest barometric formulæ, and such are the volcanos which rise in the elevated Steppe de los Pastos, itself ten thousand (10657 English) feet high. All these summits, which are of various shapes, consist of trachyte, formerly called Trap-porphyry: a granular vesicular rock composed of different kinds of feldspar (Labradorite, Oligoklase, and Albite), augite, hornblende, and sometimes interspersed mica, and even quartz. In cases where the evidence of the first outburst or eruption, or I might say where the ancient structure or scaffolding remain entire, the isolated conical mount is surrounded by an amphitheatre or lofty circular rampart of rocky strata superimposed upon each other. Such walls or ring-formed ramparts are called "craters of elevation," a great and important phenomenon, concerning which a memorable treatise was presented to our Academy five years ago (*i. e.* in 1818), by the first geologist of our time, Leopold von Buch, from whose writings I have borrowed several of the views contained in the present discussion.

Volcanos which communicate with the atmosphere through permanent openings, conical basaltic hills, and craterless trachytic domes, sometimes as low as Sarcouy, sometimes as lofty as the Chimborazo, form various groups. Comparative geography shows us sometimes small clusters or distinct systems of mountains, with craters and lava-currents in the Canaries and the Azores, and without craters and without lava-currents, properly so-called, in the Euganean hills and the Siebengebirge near Bonn;—and at other times the same study describes to us volcanos arranged in single or double lines extending through many hundred leagues in length, these lines being either parallel to the direction of a great chain of mountains, as in Guatimala, in Peru, and in Java, or cutting it transversely or at right angles, as in tropical Mexico. In this land of the Aztecs the fire-emitting trachytic mountains are the only ones which attain the elevation of the lofty region of perpetual snow; they are ranged in the direction of a parallel of latitude, and have probably been raised from a fissure 420 English geographical miles long, traversing the continent from the Pacific to the Atlantic Ocean.

These assemblages of volcanos, whether in rounded groups or in double lines, show in the most conclusive manner that the volcanic agencies do not depend on small or restricted causes, in near proximity to the surface of the earth, but that they are great phænomena of deep-seated origin. The whole of the eastern part of the American continent, which is poor in metals, is, in its present state, without fire-emitting mountains, without masses of trachyte, and perhaps even without basalt containing olivine. All the American volcanos are on the side of the continent which is opposite to Asia, in the chain of the Andes which runs nearly in the direction of a meridian, and extends over a length of 7200 geographical miles.

The whole plateau or high-land of Quito, of which Pichincha, Cotopaxi, and Tunguragua form the summits, is to be viewed as a single volcanic furnace. The subterranean fire breaks forth sometimes through one and sometimes through another of these openings, which it has been customary to regard as separate and distinct volcanos. The progressive march of the subterranean fire has been here directed for three centuries from North to South. Even the earthquakes which occasion such dreadful ravages in this part of the world afford remarkable proofs of the existence of subterranean communications, not only between countries where there are no volcanos (a fact which had long been known), but also between fire-emitting openings situated at great distances asunder. Thus in 1797 the volcano of Pasto, east of the Guaytara River, emitted uninterruptedly for three months a lofty column of smoke, which column disappeared at the instant when, at a distance of 240 geographical miles, the great earthquake of Riobamba and the immense eruption of mud called "Moya" took place, causing the death of between thirty and forty thousand persons.

The sudden appearance of the Island of Sabrina near the Azores, on the 30th of January, 1811, was the precursor of the terrible earthquake movements which, much farther to the west, shook almost incessantly, from the month of May 1811 to June 1813, first the West Indian Islands, then the plain of the Ohio and Mississipi, and lastly, the opposite coast of Venezuela or Caraccas. Thirty days after the destruction of the principal city of that province, the long tranquil volcano of the Island of St. Vincent burst forth in an eruption. A remarkable phenomenon accompanied this eruption: at the same moment when the explosion took place, on the 30th of April, 1811, a loud subterranean noise was heard in South America, which spread terror and dismay over a district of 2200 (German) geographical square miles (35200 English geographical square miles). The dwellers on the banks of the Apure near the confluence of the Rio Nula, and the most distant inhabitants of the sea coast of Venezuela, alike compared the sound to that of the discharge of great pieces of ordnance. Now from the confluence of the Nula with the Apure (by which latter river I arrived on the Orinoco) to the volcano of St. Vincent is a distance in a straight line of 628 English geographical miles. The sound, which certainly was not propagated through the air, must have proceeded from a deep-seated subterranean cause; for its intensity was scarcely greater on the sea coast nearest to the volcano where the eruption was taking place, than in the interior of the country, in the basin of the Apure and the Orinoco.

It would be unnecessary to multiply examples by citing other instances which I have collected, but, to recall a phenomenon of European historical importance, I will only farther mention the celebrated earthquake of Lisbon. Simultaneously with that event, on the 1st of November, 1755, not only were the Swiss lakes and the sea near the coast of Sweden violently agitated, but even among the eastern West Indian Islands, Martinique, Antigua, and Barbadoes, where the tide never exceeds thirty inches, the sea suddenly rose more than twenty feet. All these phenomena show the operation of subterranean forces, acting either dynamically in earthquakes, in the tension and agitation of the crust; or in volcanos, in the production and chemical alteration of substances. They also show that these forces do not act superficially, in the thin outermost crust of the globe, but from great depths in the interior of our planet, through crevices or unfilled veins, affecting simultaneously widely distant points of the earth's surface.

The greater the variety of structure in volcanos, or in the elevations which surround the channel through which the molten masses of the interior of the earth reach its surface, the greater the importance of submitting this structure to strict investigation and measurement. The interest attaching to these measurements, which formed a particular object of my researches in another quarter of the globe, is enhanced by the consideration that at many points the magnitude to be measured is found to be a variable quantity. The philosophical study of nature endeavours, in the vicissitudes of phenomena, to connect the present with the past.

If we desire to investigate either the fact of a periodical return, or the law of progressive variations or changes in phenomena, it is essential to obtain, by means of observations carefully made and connected with determinate epochs, certain fixed points which may afford a base for future numerical comparisons. If we only possessed determinations made once in each period of a thousand years, of the mean temperature of the atmosphere and of the earth in different latitudes, or of the mean height of the barometer at the level of the sea, we should know whether, and in what ratio, the temperature of different climates had increased or decreased, or whether the height of the atmosphere had undergone changes. Such points of comparison are also needed for the inclination and declination of the magnetic needle, as well as for the intensity of the magneto-electric forces, on which, within the circle of this Academy, two excellent physicists, Seebeck and Erman, have thrown so much light. As it is an honourable object for the exertions of scientific societies to trace out perseveringly the cosmical variations of temperature, atmospheric pressure, and magnetic direction and intensity, so it is the duty of the geological traveller, in determining the inequalities of the earth's surface, to attend more particularly to the variable height of volcanos. The endeavours made by me for this object in the Mexican mountains, in respect to the Volcan de Toluca, the Popocatepetl, the Cofre de Perote or Nauhcampatepetl, and the Jorullo, and also the volcano of Pichincha in the Andes of Quito, have been continued since my return to Europe at different epochs on Vesuvius. Where complete trigonometric or barometric measurements are wanting, accurate angles of altitude, taken at points which are exactly determined, may be substituted for them; and for a comparison of determinations made at different epochs, angles of altitude so measured may even be often preferable to the complication of circumstances which more complete operations may involve.

Saussure had measured Mount Vesuvius, in 1773, when the two margins of the crater, the north-western and the south-eastern, appeared to him be of equal height. He found their height above the level of the sea 609 toises, 3894 English feet. The eruption of 1794 occasioned a breaking down of the margin of the crater on the southern side, and a consequent inequality between the height of the two edges which the most unpractised eye does not fail to distinguish even at a considerable distance. In 1805, Leopold von Buch, Gay-Lussac, and myself, measured the height of Vesuvius three times, and found the northern margin opposite to La Somma, (the Rocca del Palo), exactly as given by Saussure, but the southern margin 75 toises, or 450 French or 479 English feet, lower than he had found it in 1773. The whole elevation of the volcano on the side of Torre del Greco (the side towards which, for the last thirty years, the igneous action has, as it were, been principally directed,) had at that time diminished one-eighth. The height of the cone of ashes, as compared with the whole height of the mountain, is in Vesuvius as 1 to 3; in Pichincha, as 1 to 10; and in the Peak of Teneriffe, as 1 to 22. In these three volcanic mountains, the cone of ashes is therefore, relatively speaking, highest in Vesuvius; probably because, being a low volcano, the action has been principally by the summit.

A few months ago (in 1822) I was enabled not only to repeat my former barometric measurements of the height of Vesuvius, but also, during the course of three visits to the summit, to make a more complete determination of all the edges of the crater (1). These determinations may not be without interest, since they include the long period of great eruptions between 1805 and 1822, and constitute perhaps the only known examination and measurement of a volcano at different epochs, in which the different parts of the examination are all truly comparable with each other. We learn from it that the margins of craters are a phenomenon of far more permanent character than had been previously inferred from passing observations, and this not only where (as in the Peak of Teneriffe, and in all the volcanos of the chain of the Andes,) they are visibly composed of trachyte, but also elsewhere. According to my last determinations, the north-west edge of Vesuvius has, perhaps, not altered at all since the time of Saussure, an interval of 49 years; and the south-eastern side, on the side towards Bosche Tre Case, which, in 1794, had become 400 French (426 English) feet lower, has since then hardly altered 10 toises (60 French or 64 English feet).

If the public journals, in describing great eruptions, often state the shape of Vesuvius to have undergone an entire change, and if these assertions appear to be confirmed by picturesque views sketched at Naples, the cause of the error consists in the outlines of the margin of the crater having been confounded with those of the cones of eruption accidentally formed in the middle of the crater on its floor or bottom which has been upheaved by vapours. Such a cone of eruption, consisting of loosely heaped-up rapilli and scoriæ, had in the course of the years 1816-1818 gradually risen so as to be seen above the south-eastern margin of the crater; and the eruption of the month of February 1822 augmented it so much, that it even became from 100 to 110 (about 107 to 117 English) feet higher than the north-western margin of the crater (the Rocca del Palo). This remarkable cone, which it had become customary in Naples to regard as the true summit of the mountain, fell in, with a dreadful noise, in the last eruption, on the night of the 22d of October (1822): so that the floor of the crater, which had been constantly accessible since 1811, is now 750 (almost 800 English) feet lower than the northern, and 200 (213 English) feet lower than the southern edge of the volcano. Variations in the form and relative position of the cones of eruption,—the openings of which ought not to be confounded, as they often are, with the crater of the volcano itself,—give to Vesuvius at different epochs a different appearance, which would enable a person well acquainted with the history of the volcano, on a mere inspection of Hackert's paintings in the palace of Portici, to tell from the outlines of the summit, according as the northern or the southern side of the mountain is represented as the highest, in what year the artist had taken the sketch from which the picture was made.

In the last eruption, in the night of the 23d to the 24th of October, twenty-four hours after the falling in of the great cone of scoriæ which has been mentioned, and when the small but numerous currents of lava had already flowed off, the fiery eruption of ashes and rapilli commenced: it continued without intermission for twelve days, but was greatest in the first four days. During this period the detonations in the interior of the volcano were so violent that the mere concussion of the air, (for no earthquake movement was perceived), rent the ceilings of the rooms in the palace of Portici. In the neighbouring villages of

Resina, Torre del Greco, Torre del Annunziata, and Bosche Tre Case, a remarkable phenomenon was witnessed. Throughout the whole of that part of the country the air was so filled with ashes as to cause in the middle of the day profound darkness, lasting for several hours: lanterns were carried in the streets, as has so often been done at Quito during the eruptions of Pichincha. The flight of the inhabitants had never been more general: lava currents are regarded by those who dwell near Vesuvius with less dread than an eruption of ashes, a phenomenon which had never been known to such a degree in modern times; and the obscure tradition of the manner in which the destruction of Herculaneum, Pompeii, and Stabiæ took place, filled the imaginations of men with appalling images.

The hot aqueous vapours which rose from the crater during the eruption and spread themselves in the atmosphere, formed, in cooling, a dense cloud, surrounding the column of fire and ashes, which rose to a height of between nine and ten thousand feet. So sudden a condensation of vapour, and even, as Gay-Lussac has shewn, the formation of the cloud itself, augmented the electric tension. Flashes of forked lightning, issuing from the column of ashes, darted in every direction; and the rolling thunders were distinctly heard, and distinguished from the sounds which proceeded from the interior of the volcano. In no other eruption had the play of the electric forces formed so striking a feature.

On the morning of the 26th of October, a surprising rumour prevailed, to the effect that a torrent of boiling water was gushing from the crater, and pouring down the slope of the cone of ashes. The learned and zealous observer of the volcano, Monticelli, soon discovered that this erroneous rumour had arisen from an optical illusion. The supposed torrent of water was in reality a flow of dry ashes, which, being as loose and moveable as shifting sands, issued in large quantities from a crevice in the upper margin of the crater. The cultivated fields had suffered much from a long-continued drought which had preceded the eruption; towards its close the "volcanic thunder-storm" which has been described produced an exceedingly violent and abundant fall of rain. This phenomenon is associated in all climates with the close of a volcanic eruption. As during the eruption the cone of ashes is generally enveloped in cloud, and as it is in its immediate vicinity that the rain is most violent, torrents of mud are seen to descend from it in all directions, which the terrified husbandman imagines to consist of waters which have risen from the interior of the volcano and overflowed the crater; while geologists have erroneously thought they recognised in them either sea-water or muddy products of the volcano, "Eruptions boueuses," or, in the language of some old French systematists, products of an igneo-aqueous liquefaction.

Where, as is generally the case in the Andes, the summit of the volcano rises into the region of perpetual snow, (even attaining, in some cases, an elevation twice as great as that of Etna), the melting of the snows renders such inundations as have been described far more abundant and disastrous. The phenomena in question are meteorologically connected with the eruptions of volcanos, and are variously modified by the height of the mountain, the dimensions of that part of it which is always covered with snow, and the extent and degree to which the sides of the cone of cinders become heated; but they are not to be regarded as volcanic phenomena properly so called. Vast cavities also often exist on the slope or at the foot of volcanos which, communicating through many channels with the mountain torrents, form large subterranean lakes or reservoirs of water. When earthquake shocks, which, in the Andes, usually precede all igneous eruptions, convulse the entire mass of the volcano, these subterranean reservoirs are opened, and there issue from them water, fishes, and tufaceous mud. This is the singular phenomenon which brings to light an otherwise unknown fish, the Pimelodes Cyclopum, called by the inhabitants of the highlands of Quito "Preñadilla," and which I described soon after my return. When, on the night of the 19th of June, 1698, the summit of a mountain situated to the north of Chimborazo, the Carguairazo, above 19000 English feet high, fell in, the country for nearly thirty English geographical square miles round was covered with mud and fishes; and seven years earlier a putrid fever, in the town of Ibarra, was ascribed to a similar eruption of fish from the volcano of Imbaburu.

I recall these facts, because they throw some light on the difference between the eruption of dry ashes and miry inundations of tufa and trass, carrying with them wood, charcoal, and shells. The quantity of ashes emitted by Vesuvius in the recent eruption, like every thing connected with volcanos and other great natural phenomena of a character to excite terror, has been exceedingly exaggerated in the public papers; and two Neapolitan chemists, Vicenzo Pepe and Giuseppe di Nobili, notwithstanding the statements of Monticelli and Covelli to the contrary, even describe the ashes as containing silver and gold. According to the results of my researches and inquiries, the thickness of the bed of ashes formed by the twelve days' shower was but little above three feet, towards Bosche Tre Case, on the slope of the cone where rapilli were mingled with them; and in the plain, from 15½ to 19 inches at the utmost. Such measurements ought not to be taken in places where the ashes have been heaped up by the action of wind, like drifted snow or sand, or have accumulated from being carried thither by water. The times are passed for seeking only the marvellous in volcanic phenomena, in the manner of the ancients among whom Ctesias made the ashes of Etna to be conveyed as far as the Indian peninsula. There are in Mexico veins of gold and silver in trachytic porphyry; but in the ashes of Vesuvius which I brought back with me, and which an excellent chemist, Heinrich Rose, has examined at my request, no traces of either gold or silver have been discovered.

Although the above mentioned results, which are quite in accordance with the exact observations of Monticelli, differ much from the accounts which have been current during the short interval which has elapsed, it is nevertheless true that the eruption of ashes from Vesuvius from the 24th to the 28th of last October (1822) is the most memorable of any of which we possess an authentic account, since that which occasioned the death of the elder Pliny. The quantity of ashes is, perhaps, three times as great as has ever been seen to fall since volcanic phenomena have been attentively observed in Italy. A stratum of ashes, from 16 to 19 inches thick, appears at first sight insignificant compared with the mass which we find covering Pompeii; but, not to speak of the increase which that mass has probably received by the effects of heavy rains and other causes during the centuries which have since elapsed, and without renewing the animated debate respecting the causes of the destruction of the Campanian towns, and which, on the other side of the Alps, has been carried on with a considerable degree of scepticism, it should here be recalled to recollection that the eruptions of a volcano, at widely separated epochs, do not well admit of comparison, as respects their intensity. All inferences derived from analogy are inadequate where quantitative relations are concerned; as the quantity of lava and ashes, the height of the column of smoke, and the loudness or intensity of the detonations.

From the geographical description of Strabo, and from an opinion given by Vitruvius respecting the volcanic origin of pumice, we perceive that, up to the year of the death of Vespasian, *i. e.* previous to the eruption which overwhelmed Pompeii, Vesuvius had more the appearance of an extinct volcano than of a Solfatara. When, after long repose, the subterranean forces suddenly opened for themselves new channels, and again broke through the beds of primitive and trachytic rocks, effects must have been produced for which subsequent ones do not furnish a standard. From the well-known letter in which the younger Pliny informs Tacitus of his uncle's death, it may be clearly seen that the renewal of volcanic outbursts, or what might be called the revival of the slumbering volcano, began with an eruption of ashes. The same thing was observed at Jorullo when, in September 1759, the new volcano, breaking through beds of syenite and trachyte, rose suddenly in the plain. The country-people took flight on finding their huts strewed with ashes which had been emitted from the everywhere opening ground. In the ordinary periodical manifestations of volcanic activity, on the contrary, the shower of ashes marks the termination of each particular eruption. There is a passage in the letter of the younger Pliny which shews clearly that, at a very early stage of the eruption, the dry ashes which had fallen had reached a thickness of four or five feet, without accumulation from drift or other extraneous cause. He writes, in the course of his narrative, "the court which had to be crossed to reach the room in which Pliny was taking his noon-day repose was so filled with ashes and pumice, that, if he had longer delayed coming forth, he would have found the passage stopped." In an enclosed space like a court, the action of wind in drifting the ashes can scarcely have been very considerable.

I have interrupted my general comparative view of volcanos by a notice of particular observations made on Vesuvius, partly on account of the great interest excited by the recent eruption, and partly on account of those recollections of the catastrophes of Pompeii and Herculaneum, which are almost involuntarily recalled to our minds by the occurrence of any considerable shower of ashes. I have recorded in a note the measurements of height made by myself and others on Vesuvius and in its vicinity.

We have hitherto been considering the structure and mode of action of those volcanos which have a permanent communication with the interior of the Earth by craters. The summits of such volcanos consist of masses of trachyte and lava upheaved by elastic forces and traversed by veins. The permanency of their action gives us reason to infer great complexity of structure. They have, so to speak, an individual character which remains unaltered for long periods of time. Neighbouring mountains often present the greatest differences in their products: leucitic and feldspathic lavas, obsidian with pumice, and masses of basalt containing olivine. They belong to the most recent terrestrial phænomena, breaking through almost all the sedimentary strata, and their products and lava currents are of later origin than our valleys. Their life, if I may permit myself to employ this figurative mode of expression, depends on the manner and permanence of their communications with the interior of the Earth. They often continue for centuries in a state of repose, are then suddenly rekindled, and end by becoming Solfataras, emitting aqueous vapours, gases, and acids; sometimes, however, as in the case of the Peak of Teneriffe, we find that their summit has already become a laboratory of regenerated sulphur; while from the sides of the mountain there still issue large torrents of lava, basaltic in the lower part, but towards the upper part, where the pressure is less, (2) presenting the form of obsidian with pumice.

Distinct from these volcanos provided with permanent craters, there is another class of volcanic phenomena more rarely observed, but particularly instructive to the geologist, as they recall the ancient world or the earliest geological revolutions of our planet. Trachytic mountains open suddenly, emit lava and ashes, and close again, perhaps never to reopen. Thus it was with the gigantic mountain of Antisana in the chain of the Andes, and with the Monte Epomeo in Ischia in 1302. Sometimes such an outbreak has even taken place in plains: as in the high plateau of Quito, in Iceland at a distance from Mount Hecla, and in Eubœa in the Lelantine Fields. Many of the upheaved islands belong to this class of transitory phænomena. In all these cases the communication with the interior of the earth is not permanent, and the action ceases as soon as the cleft or fissure forming a temporary channel closes again. Veins or dykes of basalt, dolerite, and porphyry, which in different parts of the earth traverse almost all formations, and masses of syenite, augitic porphyry, and amygdaloid, which characterise the recent transition and oldest sedimentary rocks, have probably been formed in a similar manner. In the youth of our planet, the substances of the interior being still fluid, penetrated through the everywhere fissured crust of the globe, sometimes becoming solidified in the form of rocky veins or dykes of granular texture, and sometimes spreading out in broad sheets, and resembling superimposed strata. The volcanic products or rocks transmitted to us from the earlier ages of our planet have not flowed in narrow bands like the lavas of the isolated conical volcanos of the present time. The mixtures of augite, titaniferous iron, feldspar, and hornblende, may have been the same at different epochs, sometimes approximating more to basalt and sometimes to trachyte; and, (as we learn from the important researches of Mitscherlich, and the analogy of artificial igneous products) chemical substances may have united in definite proportions in a crystalline form: in all cases we recognise that substances similar in composition have arrived at the surface of the earth by very different ways; either simply upheaved, or penetrating through temporary fissures; and that breaking through the older rocks, (*i. e.* the earlier oxydized crust of the globe), they have finally issued as lava currents from conical mountains having a permanent crater. To confound together phenomena so different is to throw the geological study of volcanos and volcanic action back into the obscurity from which, by the aid of numerous comparative observations and researches, it has gradually began to emerge.

The question has often been propounded: What is it that burns in volcanos,—What produces the heat which melts and fuses together earths and metals? Modern chemical science has essayed to answer, that what burns are the earths, the metals, the alkalies themselves; viz. the metalloids of those substances. The solid and already-oxydised crust of the globe separates the surrounding atmosphere, with the oxygen which it contains, from the inflammable unoxydised substances in the interior of our planet: when those metalloids come in contact with the oxygen of the atmosphere there arises disengagement of heat. The great and celebrated chemist who propounded this explanation of volcanic phenomena soon himself relinquished it. Observations made in mines and caverns in all climates, and which in concert with M. Arago I have collected in a separate memoir, shew that, even at what may be considered a very small depth, the temperature of the Earth is much above the mean temperature of the atmosphere at the same place. A fact so remarkable, and so generally confirmed, connects itself with that which we learn from volcanic phenomena. The depth at which the globe may be regarded as a molten mass has been calculated. The primitive cause of this subterranean heat is, as in all planets, the process of formation itself, the separation of the spherically condensing mass from a cosmical gaseous fluid, and the cooling of the terrestrial strata at different depths by the loss of heat parted with by radiation. All volcanic phenomena are probably the result of a communication either permanent or transient between the interior and exterior of the globe. Elastic vapours press the molten oxydising substances upwards through deep fissures. Volcanos might thus be termed intermitting springs or fountains of earthy substances; *i. e.* of the fluid mixture of metals, alkalis, and earths which solidify into lava currents and flow softly and tranquilly, when being upheaved they find a passage by which to escape. In a similar manner the Ancients represented (according to Plato's Phædon) all volcanic fiery currents as streams flowing from the Pyriphlegethon.

To these considerations and views let me be permitted to add another more bold. May we not find in this internal heat of our globe,—(a heat indicated by thermometric experiments on the waters of springs rising from different depths, (3) as well by our observations on volcanos),—a cause which may explain one of the most wonderful phænomena with which the study of fosssils has made us acquainted? Tropical forms of animals, and, in the vegetable kingdom, arborescent ferns, palms, and bambusaceæ, are found buried in the cold regions of the North. Everywhere the ancient world shews a distribution of organic forms at variance with our present climates. To resolve so important a problem, recourse has been had to several hypotheses; such as the approach of a comet, a change in the obliquity of the Ecliptic, and a different degree of intensity in the solar light. None of these explanations are satisfactory at once to the astronomer, the physicist, and the geologist. For my part I willingly leave the axis of the Earth in its place, and suppose no change in the light of the solar disk (from whose spots a celebrated astronomer was inclined to explain the favourable or unfavourable harvests of particular years); I am disposed to recognise that in each planet there exist, independently of its relations to the central body of the system to which it belongs, and independently of its astronomical position, various causes for the development of heat;—processes of oxydation, precipitations and chemical changes in the capacity of bodies, by increase of electro-magnetic intensity, and communications opened between the internal and external portions of the planet.

It may be that in the Ancient World, exhalations of heat issuing forth through the many openings of the deeply fissured crust of the globe may have favoured, perhaps for centuries, the growth of palms and tree-ferns and the existence of animals requiring a high temperature, over entire countries where now a very different climate prevails. According to this view of things (a view already indicated by me in a work entitled "Geological Essay on the Superposition of Rocks in both Hemispheres") the temperature of volcanos would be that of the interior of the earth, and the same cause which, operating through volcanic eruptions, now produces devastating effects, might in primeval ages have clothed the deeply fissured rocks of the newly oxydised earth in every zone with the most luxuriant vegetation.

If, with a view to explain the distribution of tropical forms whose remains are now discovered buried in northern regions, it should be assumed that the long-haired species of Elephant now found enclosed in ice was originally indigenous in cold climates, and that forms resembling the same leading type may, as in the case of lions and lynxes, have been able to live in wholly different climates, still this manner of solving the difficulty presented by fossil remains cannot be extended so as to apply to vegetable productions. From reasons with which the study of vegetable physiology makes us acquainted, Palms, Musaceæ, and arborescent Monocotyledones, are incapable of supporting the deprivation of their appendicular organs which would be caused by the present temperature of our northern regions; and in the geological problem which we have to examine, it appears to me difficult to separate vegetable and animal remains from each other. The same mode of explanation ought to comprehend both.

I have permitted myself at the conclusion of the present discussion to connect with facts collected in different and widely separated countries some uncertain and hypothetical conjectures. The philosophical study of Nature rises beyond the requirements of a simple description of Nature: it does not consist in a sterile accumulation of isolated facts. It may sometimes be permitted to the active and curious mind of man to stretch forward from the present to the still obscure future; to divine that which cannot yet be clearly known; and thus to take pleasure in the ancient myths of geology reproduced in our own days in new and varied forms.

ANNOTATIONS AND ADDITIONS.

(1) p. 226.—" *A more complete determination of the height of all parts of the margin of the crater.*"

Oltmanns, my astronomical fellow labourer, of whom, alas! science has been early deprived, re-calculated the barometric measurements of Vesuvius referred to in the preceding memoir (of the 22d and 25th of November and of the 1st of December, 1822), and has compared the results with the measurements which have been communicated to me in manuscript by Lord Minto, Visconti, Monticelli, Brioschi, and Poulett Scrope.

A. *Rocca del Palo, the highest and northern margin of the Crater of Vesuvius.*

	Toises.		Eng. ft.
Saussure, barometric measurement computed in 1773, probably by Deluc's formula . . .	609	—	3894
Poli, 1794, barometric	606	—	3875
Breislak, 1794, barometric (but, like Poli, the formula employed uncertain)	613	—	3920
Gay-Lussac, Leopold von Buch, and Humboldt, 1805, barometric, computed by Laplace's formula, as are also all the barometric results which follow .	603	—	3856
Brioschi, 1810, trigonometric	638	—	4080
Visconti, 1816, trigonometric	622	—	3977
Lord Minto, 1822, barometric, often repeated .	621	—	3971

	Toises.		Eng. ft.
Poulett Scrope, 1822, barometric, somewhat uncertain from the proportion between the diameters of the tube and cistern being unknown	604	—	3862
Monticelli and Covelli, 1822.	624	—	3990
Humboldt, 1822	629	—	4022

Most probable result 317 toises, or 2027 English feet, above the Hermitage; or 625 toises, or 3996 English feet, above the level of the sea.

B. *The lowest and southern margin of the crater opposite to Bosche Tre Case.*

	Toises.		Eng. ft.
After the eruption of 1794 this edge became 400 (426 Eng.) feet lower than the Rocca del Palo; therefore if we estimate the latter at 625 toises (3996 English feet)	559	—	3574
Gay-Lussac, Leopold von Buch, and Humboldt, 1805, barometric	534	—	3414
Humboldt, 1822, barometric	546	—	3491

C. *Height of the cone of scoriæ inside the crater, which fell in on the 22d of October*, 1822.

	Toises.		Eng. ft.
Lord Minto, barometric	650	—	4156
Brioschi, trigonometric, according to different combinations either	636	—	4066
Or	641	—	4098

Probable final result for the height of the above-mentioned cone of scoriæ 646 toises, or 4130 English feet.

D. *Punta Nasone, highest summit of the Somma.*

	Toises.		Eng. ft.
Schuckburgh, 1794, barometric, probably computed by his own formula	584	—	3734
Humboldt, 1822, barometric, Laplace's formula	586	—	3747

E. *Plain of the Atrio del Cavallo.*

	Toises.		Eng. ft.
Humboldt, 1822, barometric	403	—	2577

F. *Foot of the cone of ashes.*

	Toises.		Eng. ft.
Gay-Lussac, Leopold von Buch, and Humboldt, 1805, barometric	370	—	2366
Humboldt, 1822, barometric	388	—	2481

G. *Hermitage del Salvatore.*

	Toises.		Eng. ft.
Gay-Lussac, Leopold von Buch, and Humboldt, 1805, barometric	300	—	1918
Lord Minto, 1822, barometric	307·9	—	1969
Humboldt, 1822, barometric repeated . . .	308·7	—	1974

Part of my measurements have been printed in Monticelli's Storia de' fenomeni del Vesuvio, avvenuti negli anni 1821-1823, p. 115; but the neglected correction for the height of the mercury in the cistern has somewhat disfigured the results as there published. When it is remembered that the results given in the above table were obtained with barometers of very different constructions, at various hours of the day, with winds from very different quarters, and on the unequally heated declivity of a volcano, in a locality in which the decrease of atmospheric temperature differs greatly from that which is supposed in our barometric formulæ,—the agreement will be found to be as great as could be expected, and quite satisfactory.

My measurements in 1822, at the time of the Congress of Verona, when I accompanied the late King of Prussia to

Naples, were made with more care and under more favourable circumstances than those of 1805. Differences of height are besides always to be preferred to absolute heights, and these show that since 1794 the difference between the heights of the edges of the crater at the Rocca del Palo and on the side towards Bosco Tre Case has continued almost the same. I found it in 1805 exactly 69 toises (441 English feet), and in 1822 almost 82 toises (524 English feet). A distinguished geologist, Mr Poulett Scrope, found 74 toises (473 English feet), although the absolute heights which he assigns to the two sides of the crater appear to be rather too small. So little variation in a period of twenty-eight years, in which there were such violent commotions in the interior of the crater, is certainly a striking phænomenon.

The height attained by cones of scoriæ rising from the floor of the crater of Vesuvius is also deserving of particular attention. In 1776 Schuckburgh found such a cone 615 toises, or 3932 English feet, above the surface of the Mediterranean: according to the measurements of Lord Minto, (a very accurate observer,) the cone of scoriæ which fell in on the 22d of October, 1822, even attained the height of 650 toises, or 4156 English feet. On both occasions, therefore, the height of the cones of scoriæ in the crater surpassed that of the highest part of the margin of the crater. When we compare together the measurements of the Rocca del Palo from 1773 to 1822, we are almost involuntarily led to entertain the bold conjecture that the north margin of the crater has been gradually upraised by subterranean forces. The accordance of the three measurements between 1773 and 1805 is almost as striking as that of those taken from 1816 to 1822. In the latter period we cannot doubt the height being from about 621 to 629 toises (3970 to 4022 English feet). Are the measurements made from thirty to forty years earlier, which gave only 606 to 609 toises (3875 to 3894 English feet), less certain? At some future day, after longer periods shall have elapsed, it will be possible to decide what is due to errors of measurement, and what to an actual rise in the margin of the crater. There cannot be in this case any accumulation of loose materials from above. If the solid trachyte-like lava beds of the Rocca del Palo really become higher, we must assume them to be upheaved from below by volcanic forces.

My learned and indefatigable friend Oltmanns has placed all the details of the above measurements before the public, accompanied by a careful critical examination of them, in the Abhandl. der königl. Akademie der Wissenschaften zu Berlin, 1822-1823, S. 3-20. May this investigation be the means of inducing geologists frequently to examine hypsometrically this low and most easily accessible (except Stromboli) of the European volcanos, so that in the course of centuries there may be obtained a frequently checked and accurate account of its periods of development!

(2) p. 235.—"*Where the pressure is less.*"

Compare Leopold von Buch on the Peak of Teneriffe in his Physikalische Beschreibung der canarischen Inseln, 1825, S. 213; and in the Abhandlungen der königl. Akademie zu Berlin, 1820-1821, S. 99.

(3) p. 239.—"*Waters of springs rising from different depths.*"

Compare Arago in the Annuaire du Bureau des Longitudes pour 1835, p. 234. The increase of temperature is in our latitudes 1° of Reaumur (2°.25 of a degree of Fahrenheit) for every 113 Parisian feet (120.5 English feet), or 1° Fah. to 53.5 English feet nearly. In the Artesian boring at New Salzwerk (Oeynhausen's Bad), not far from Minden, which is the greatest known depth below the level of the sea, the temperature of the water at 2094½ Parisian feet (2232¼ Eng.) is fully 26°.2 Reaumur, or 91° Fahr.; while the mean temperature of the air above may be taken at 7°.7 Reaumur, or 49°.2 Fahr. It is very remarkable that in the third century Saint Patricius, Bishop of Pertusa, was led by seeing the hot springs near Carthage to a very just view respecting the cause of such an increase of heat. (Acta S. Patricii, p. 555, ed. Ruinart; Kosmos, Bd. i. S. 231,—English Edition, Vol. i. p. 211.)

THE

VITAL FORCE;

OR,

THE RHODIAN GENIUS.

[FIRST PRINTED IN 1795.]

THE VITAL FORCE,

OR

THE RHODIAN GENIUS.

The Syracusans, like the Athenians, had their Pœcile, in which representations of gods and heroes, the works of Grecian and Italian art, adorned the halls, glowing with varied colours. The people resorted thither continually; the young warriors to contemplate the exploits of their ancestors, the artists to study the works of the great masters. Among the numerous paintings which the active zeal of the Syracusans had collected from the mother country, there was one which, for a century past, had particularly attracted the attention of spectators. Sometimes the Olympian Jove, Cecrops the founder of cities, and the heroic courage of Harmodius and Aristogiton, would want admirers, while men pressed in crowded ranks around the picture of which we speak. Whence this preference? Was it a rescued work of Apelles, or of the school of Callimachus? No; it possessed indeed grace and beauty; but yet neither in the blending of the colours, nor in the character and style of the entire picture, could it be compared with many other paintings in the Pœcile.

The multitude (comprehending therein many classes of society), often regard with astonishment and admiration what they do not comprehend : this picture had occupied its place for a hundred years; but though Syracuse contained within the narrow limits enclosed by its walls more of the genius of art than the whole of the remainder of sea-surrounded Sicily, no one had yet divined the hidden meaning of the design. It was even uncertain to what temple the painting had originally belonged, for it had been rescued from a shipwrecked vessel, which was only conjectured from the merchandise it contained to have come from Rhodes.

On the foreground of the picture youths and maidens formed a closely crowded group. They were without clothing and well formed, but at the same time did not exhibit the more noble and graceful proportions admired in the statues of Praxiteles and Alcamenes. Their robust limbs, shewing the traces of laborious efforts, and the purely terrestrial expression of their desires and sorrows, seemed to take from them every thing of a diviner character, and to chain them exclusively to their earthly habitation. Their hair was simply ornamented with leaves and field-flowers. Their arms were outstretched towards each other, as if to indicate their desire of union, but their troubled looks were turned towards a Genius who, surrounded by bright light, hovered in the midst. A butterfly was placed on his shoulder, and in his hand he held on high a lighted torch. The contours of his form were soft and child-like, but his glance was animated by celestial fire : he looked down as a master upon the youths and maidens at his feet. Nothing else that was characteristic could be discovered in the picture. Some persons thought they could make out at its foot the letters ζ and ς, from whence (as antiquaries were then no less bold in their conjectures than they now are), they took occasion to infer, in a somewhat forced manner, the name of Zenodorus; thus attributing the work to a painter of the same name as the artist who at a later period cast the Colossus of Rhodes.

The "Rhodian Genius," however,—for such was the name given to the picture,—did not want for commentators and interpreters in Syracuse. Amateurs of the arts, and especially the younger amongst them, on returning from a short visit to Corinth or Athens, would have thought it equivalent to renouncing all pretensions to connoisseurship if they had not been provided with some new explanation. Some regarded the Genius as the personification of Spiritual Love, forbidding the enjoyment of sensual pleasures; others said it was the assertion of the empire of Reason over Desire: the wiser among the critics were silent, and presuming some high though yet undiscovered meaning, examined meanwhile with pleasure the simple composition of the picture.

Still, however, the question remained unsolved. The picture had been copied with various additions and sent to Greece, but not the least light had been thrown on its origin; when at length, at the season of the early rising of the Pleiades, and soon after the reopening of the navigation of the Egean Sea, ships from Rhodes entered the port of Syracuse, bearing a precious collection of statues, altars, candelabras, and paintings, which Dionysius's love of art had caused to be brought together from different parts of Greece.

Among the paintings was one which was immediately recognised as the companion or pendent of the Rhodian Genius: the dimensions were the same, and the colouring similar, but in a better state of preservation: the Genius was still the central figure, but the butterfly was no longer on his shoulder; his head was drooping, and his torch extinguished and inverted. The youths and maidens pressing around him had met and embraced; their glance, no longer subdued or sad, announced, on the contrary, emancipation from restraint, and the fulfilment of long-cherished desires.

The Syracusan antiquaries were already seeking to modify the explanations they had previously proposed, so as to adapt them to the newly-arrived picture, when Dionysius commanded the latter to be carried to the house of Epicharmus, a philosopher of the Pythagorean school, who dwelt in a remote part of Syracuse called Tyche. Epicharmus rarely presented himself at the court of Dionysius, for although the latter was fond of calling around him the most distinguished men from all the Greek colonial cities, yet the philosopher found that the proximity of princes takes even from men of the greatest intellectual power part of their spirit and their freedom. He devoted himself unceasingly to the study of natural things, their forces or powers, the origin of animals and plants, and the harmonious laws in accordance with which the heavenly bodies, as well as the grains of hail and the flakes of snow, assume their distinctive forms. Oppressed with age, and unable to proceed far without assistance, he caused himself to be conducted daily to the Pœcile, and thence to the entrance of the port, where, as he said, his eyes received the image of the boundless and the infinite which his spirit ever strove in vain to apprehend. He lived honoured alike by the tyrant, whose presence he avoided, and by the lower classes of the people, whom he met gladly, and often with friendly help.

Exhausted with fatigue, he was reposing on his couch, when the newly-arrived picture was brought to him by the command of Dionysius. Care had been taken to bring, at the same time, a faithful copy of the "Rhodian Genius," and the philosopher desired the two paintings to be placed side by side before him. After having remained for some time with his eyes fixed upon them, and absorbed in thought, he called his scholars together, and spoke to them in the following terms, in a voice which was not without emotion :—

"Withdraw the curtain from the window, that I may enjoy once more the view of the fair earth animated with living beings. During sixty years I have reflected on the internal motive powers of nature, and on the differences of substances : to-day for the first time the picture of the Rhodian Genius leads me to see more clearly that which I had before only obscurely divined. As living beings are impelled by natural desires to salutary and fruitful union, so the raw materials of inorganic nature are moved by similar impulses. Even in the reign of primeval night, in the darkness of chaos, elementary principles or substances sought or shunned each other in obedience to indwelling dispositions of amity or enmity. Thus the fire of heaven follows metal, iron obeys the attraction of the loadstone, amber rubbed takes up light substances, earth mixes with earth, salt collects together from the water of the sea, and the acid moisture of the Stypteria (στυπτηρια υγρα), as well as the flocculent salt Trichitis, love the clay of Melos. In inanimate nature all things hasten to unite with each other according to their particular laws. Hence no terrestrial element (and who would dare to include light among the number of such elements?) is to be found anywhere in its pure and primitive simple state. Each as soon as formed tends to enter into new combinations, and the art of man is needed to disjoin and present in a separated state substances which you would seek in vain in the interior of the earth, and in the fluid oceans of air or water. In dead inorganic matter, entire inactivity and repose reign so long as the bonds of affinity continue undissolved, so long as no third substance comes to join itself to the others. But even then, the action and disturbance produced are soon again succeeded by unfruitful repose.

"It is otherwise, however, when the same substances are brought together in the bodies of plants and animals. In these the vital force or power reigns supreme, and regardless of the mutual amity or enmity of the atoms recognised by Democritus, commands the union of substances which in inanimate nature shun each other, and separates those which are ever seeking to enter into combination.

"Now come nearer to me, my friends; look with me on the first of the pictures before us, and recognise in the Rhodian Genius, in the expression of youthful energy, in the butterfly on his shoulder, and in the commanding glance of his eye, the symbol of vital force animating each individual germ of the organic creation. At his feet are the earthy elements desiring to mix and unite, conformably to their particular tendencies. The Genius, holding aloft his lighted torch with commanding gesture, controls and constrains them, without regard to their ancient rights, to obey his laws.

"Now view with me the new picture which the tyrant has sent to me for explanation: turn your eyes from the image of life to that of death. The butterfly has left its former place and soars upwards; the extinguished torch is reversed, the head of the youth has sunk: the spirit has fled to other spheres, and the vital force is dead. Now the youths and maidens joyfully join hands, the earthy substances resume their ancient rights: they are freed from the chains that bound them, and follow impetuously after long restraint the impulse to union.—Thus inert matter, animated awhile by vital force, passes through an innumerable diversity of forms, and perhaps in the same substance which once enshrined the spirit of Pythagoras, a poor worm may have enjoyed a momentary existence.

"Go, Polycles, and tell Dionysius what thou hast heard;—and you my friends, Euryphamos, Lysis, and Scopas, come nearer to me and support me; I feel that in my weakened frame the enfeebled vital power will not long hold in subjection the earthly substances which reclaim their ancient liberty. Lead me once again to the Pœcile, and thence to the sea shore; soon you will collect my ashes."

NOTE.

I HAVE noticed in the Preface to the Second and Third Editions (S. xiii., p. xii. English Trans.) the subject of the republication here of the preceding pages, which were first printed in Schiller's Horen (Jahrg. 1795, St. 5, S. 90-96). They contain the development of a physiological idea clothed in a semi-mythical garb. In the Latin "Aphorisms from the Chemical Physiology of Plants" appended to my "Subterranean Flora," in 1793,—I had defined the "vital force" as "the unknown cause which prevents the elements from following their original affinities." The first of my aphorisms were as follows:—"Rerum naturam si totam consideres, magnum atque durabile, quod inter elementa intercedit, discrimen perspicies, quorum altera affinitatum legibus obtemperantia, altera, vinculis solutis, varie juncta apparent. Quod quidem discrimen in elementis ipsis eorumque indole neutiquam positum, quum ex sola distributione singulorum petendum esse videatur. Materiam segnem, brutam, inanimam eam vocamus, cujus stamina secundum leges chymicæ affinitatis mixta sunt. Animata atque organica ea potissimum corpora appellamus, quæ, licet in novas mutari formas perpetuo tendant, vi interna quadam continentur, quominus priscam sibique insitam formam relinquant.

"Vim internam, quæ chymicæ affinitatis vincula resolvit, atque obstat, quominus elementa corporum libere conjungantur, vitalem vocamus. Itaque nullum certius mortis criterium putredine datur, qua primæ partes vel stamina rerum, antiquis juribus revocatis, affinitatum legibus parent. Corporum inanimorum nulla putredo esse potest." (Vide Aphorismi ex doctrina Physiologiæ chemicæ Plantarum, in Humboldt, Flora Fribergensis subterranea, 1793, p. 133-136).

I have placed in the mouth of Epicharmus the above propositions, which were disapproved by the acute Vicq d'Azyr, in his Traité d'Anatomie et de Physiologie, T. i. p. 5, but are now entertained by many distinguished persons among my friends. Reflection and continued study in the domains of physiology and chemistry have deeply shaken my earlier belief in a peculiar so-called vital force. In 1797, at the close of my work entitled "Versuche über die gereizte Muskel und Nervenfaser, nebst Vermuthungen über den chemischen Process des Lebens in der Thier und Pflanzenwelt" (Bd. ii. S. 430-436), I already declared that I by no means regarded the existence of such peculiar vital forces as demonstrated. Since that time I have no longer called peculiar forces what may possibly only be the operation of the concurrent action of the several long-known substances and their material forces. We may, however deduce from the chemical relations of the elements a safer definition of animate and inanimate substances, than the criteria which are taken from voluntary motion, from the circulation of fluids within solids, from internal appropriation, and from the fibrous arrangements of the elements. I term that an animated substance "of which the parts being separated by external agency alter their state of composition after the separation, all other and external relations continuing the same." This definition is merely the enunciation of a fact. The equilibrium of the elements in animated or organic matter is preserved by their being parts of a whole. One organ determines another, one gives to another its temperature and tone or disposition, in all which, these, and no other, affinities are operative. Thus in organised beings all is reciprocally means and end. The rapidity with which organic parts, separated from a complete living organism, change their state of combination, differs greatly, according to the degree of their original dependence, and to the nature of the substance. Blood of animals, which varies much in the different classes, suffers change sooner than the juices of plants. Funguses generally decay sooner than leaves of trees, and muscle more easily than the cutis.

Bones, the elementary structure of which has been very recently recognised, hair of animals, wood in plants or trees, the feathery appendages of seeds of plants (Pappus), are not inorganic or without life; but even in life they approximate to the state in which they are found after their separation from the rest of the organism. The higher the degree of vitality or susceptibility of an animated substance, the more rapidly does organic change in its composition ensue after separation. "The aggregate total of the cells is an organism, and the organism lives so long as the parts are active in subservience to the whole. In opposition to lifeless or inorganic, organic nature *appears* to be self-determining." (Henle, Allgemeine Anatomie, 1841, S. 216-219). The difficulty of satisfactorily referring the vital phenomena of organic life to physical and chemical laws, consists chiefly (almost as in the question of predicting meteorological processes in the atmosphere), in the complication of the phænomena, and in the multiplicity of simultaneously acting forces and of the conditions of their activity.

I have remained faithful in "Kosmos" to the same mode of viewing and representing what are called "Lebenskräfte," vital forces, and vital affinities, (Pulteney, in the Transact. of the Royal Soc. of Edinburgh, vol. xvi. p. 305), the formation-impulse, and the active principle in organisation. I have said, in Kosmos, Bd. i. S. 67, (English Ed. vol. i. p. 62), "The myths of imponderable matter and of vital forces peculiar to each organism have complicated and perplexed the view of nature. Under different conditions and forms of recognition the prodigious mass of our experimental knowledge has progressively accumulated, and is now enlarging with increased rapidity. Investigating reason essays from time to time with varying success to break through ancient forms and symbols, invented to effect the subjection of rebellious matter, as it were, to mechanical constructions." Farther on in the same volume, (p. 339 English, and 367 of the original,) I have said, "In a physical description of the universe, it should still be noticed that the same substances which compose the organic forms of plants and animals are also found in the inorganic crust of the globe; and that the same forces or powers which govern inorganic matter are seen to prevail in organic beings likewise, combining and decomposing the various substances, regulating the forms and properties of organic tissues, but acting in these cases under complicated conditions yet unexplained, to which the very vague terms of 'vital phænomena,' 'operations of vital forces,' have been assigned, and which have been systematically grouped, according to analogies more or less happily imagined." (Compare also the critical notices on the assumption of proper or peculiar vital forces in Schleiden's Botanik als inductive Wissenchaft (Botany as an Inductive Science), Th. i. S. 60, and in the recently published excellent Untersuchungen über thierische Elektricität (Researches on Animal Electricity), by Emil du Bois-Reymond, Bd. i. S. xxxiv.-l.)

THE

PLATEAU OF CAXAMARCA,

THE

ANCIENT CAPITAL OF THE INCA ATAHUALLPA:

AND

THE FIRST VIEW OF THE PACIFIC OCEAN, FROM THE CREST OF THE ANDES.

THE
PLATEAU OF CAXAMARCA,
THE ANCIENT CAPITAL OF THE INCA ATAHUALLPA.

After a residence of an entire year on the crest of the chain of the Andes or Antis (1), between 4° North and 4° South Latitude, in the high plains of New Granada, Pastos, and Quito, whose mean elevations range between 8500 and 12800 English feet, we rejoiced in descending gradually through the milder climate of the Quina-yielding forests of Loxa to the plains of the upper part of the course of the Amazons, a terra incognita rich in magnificent vegetation. The small town of Loxa has given its name to the most efficacious of all the species of medicinal Fever-Bark: Quina, or Cascarilla fina de Loxa. It is the precious production of the tree which we have described botanically as Cinchona condaminea, but which, under the erroneous impression that all the kinds of the Quina or fever bark of commerce were furnished by the same species of tree, had previously been called Cinchona officinalis. The Fever Bark was first brought to Europe towards the middle of the seventeenth century, either, as Sebastian Badus asserts, to Alcala de Henares in 1632, or to Madrid in 1640, on the arrival of the wife of the Viceroy, the Countess of Chinchon(2), who had been cured of intermittent fever at Lima, accompanied by her physician, Juan del Vego. The trees which yield the finest quality of Quina de Loxa are found from 8 to 12 miles to the south east of the town, in the mountains of Uritusinga, Villonaco, and Rumisitana, growing on mica-slate and gneiss, at very moderate elevations above the level of the sea, being between 5400 and 7200 (5755 and 7673 English) feet, heights about equal respectively to those of the Hospice on the Grimsel and the Pass of the great St. Bernard. The proper boundaries of the Quina-woods in this quarter are the small rivers Zamora and Cachiyacu.

The tree is cut down in its first flowering season, or in the fourth or seventh year of its age, according as it has sprung from a vigorous root-shoot, or from a seed: we heard with astonishment that at the period of my journey, according to official computations, the collectors of Quina (Cascarilleros and Cazadores de Quina, Quina Hunters),—only brought in 110 hundred weight of the Bark of the Cinchona condaminea annually. None of this precious store found its way at that time into commerce; the whole was sent from the port of Payta on the Pacific, round Cape Horn to Cadiz, for the use of the Spanish Court. In order to furnish this small quantity of 11000 Spanish pounds, eight or nine hundred trees were cut down every year. The older and thicker stems have become more and more scarce;

but the luxuriance of vegetation is such that the younger trees which are now resorted to, though only 6 inches in diameter, often attain from 53 to 64 English feet in height. This beautiful tree, which is adorned with leaves above 5 English inches long and 2 broad, growing in dense woods, seems always to aspire to rise above its neighbours. As its upper branches wave to and fro in the wind, their red and shining foliage produces a strange and peculiar effect recognisable from a great distance. The mean temperature in the woods where the Cinchona condaminea is found, ranges between 12½° and 15° Reaumur (60°.2 and 65°.8 Fahrenheit), which are about the mean annual temperatures of Florence and the Island of Madeira; but the extremes of heat and cold observed at these two stations of the temperate zone are never felt around Loxa. Comparisons between the climates of places, one of which is situated in an elevated tropical plain, and the other in a higher parallel of latitude, can be from their nature but little satisfactory.

In order to descend South-South-East from the mountain knot of Loxa to the hot Valley of the Amazons, it is first necessary to pass over the *Paramos* of Chulucanas, Guamani and Yamoca,—mountain wildernesses of a peculiar character of which we have already spoken, and to which, in the southern parts of the Andes, the name of Puna (a word belonging to the Quichua language) is given. They mostly rise above 9500 (10125 English) feet; they are stormy, often enveloped for days in dense mist, or visited by violent and formidable showers of hail,—consisting not merely of hailstones of different spherical forms, usually a good deal flattened by rotation, but also sometimes of less regular forms, the hail having run together into thin plates of ice (papa-cara) which cut the face and hands. At such times I have occasionally seen the thermometer sink to 7° or 5° Reaumur, (47°.8 and 43°.2 Fahr.) and the electric tension of the atmosphere, measured by Volta's electrometer, pass in a few minutes from positive to negative. When the temperature sinks below 5° Reaumur, (43°.2 Fahrenheit) snow falls in large and thinly scattered flakes. The vegetation of the Paramos has a peculiar physiognomy and character, from the absence of trees, the short close branches of the small-leaved myrtle-like shrubs, the large sized and numerous blossoms, and the perpetual freshness of the whole from the constant and abundant supply of moisture. No zone of Alpine vegetation in the temperate or cold parts of the globe can well be compared with that of the Paramos in the tropical Andes.

The impressions produced on the mind by the natural characters of these wildernesses of the Cordilleras are heightened in a remarkable and unexpected manner, from its being in those very regions that we still see admirable remains of the gigantic work, the artificial road of the Incas, which formed a line of communication through all the provinces of the Empire, extending over a length of more than a thousand English geographical miles. We find, placed at nearly equal distances apart, stations consisting of dwelling houses built of well-cut stone; they are a kind of Caravanserai, and are called Tambos and sometimes Inca-pilca (from *pircca,* the wall?). Some of them are surrounded by a kind of fortification; others were constructed for baths with arrangements for conducting hot water; the larger were designed for the use of the family of the Monarch himself. I had previously seen, measured, and drawn with care, buildings of the same kind in a good state of preservation at the foot of the volcano of Cotopaxi, near Callo. Pedro de Cieça, writing in the 16th century, called them "Aposentos de Mulalo." (³) In the pass between Alausi and Loxa, called the Paramo del Assuay,—(a much frequented route across the Ladera de Cadlud, 14568 French or 15526 English feet above the level of the sea, or almost equal to the height of Mont Blanc),—as we were leading our heavily laden mules with great difficulty through the marshy ground on the elevated plain del Pullal, our eyes meanwhile were continually dwelling on the grand remains of the Inca's road, which with a breadth of twenty-one English feet ran by our side for above a German mile. It had a deep under-structure, and was paved with well-cut blocks of blackish trap-porphyry. Nothing that I had seen of the remains of Roman roads in Italy, in the South of France, and in Spain, was more imposing than these works of the ancient Peruvians, which are moreover situated, according to my barometric measurements, at an elevation of 12440 (13258 English) feet above the sea, or more than a thousand feet higher than the summit of the Peak of Teneriffe. The ruins of what is called the Palace of the Inca Tupac Yupanqui, and which are known by the name of the "Paredones del Inca," are situated at the same elevation on the Assuay. Proceeding from thence to the southward towards Cuenca, the road leads to the small but well preserved fortress of Cañar (4), belonging probably to the same period, that of Tupac Yupanqui, or to that of his warlike son, Huayna Capac.

We saw still finer remains of the old Peruvian artificial roads on the way between Loxa and the Amazons, at the Baths of the Incas on the Paramo de Chulucanas, not far from Guancabamba, and in the neighbourhood of Ingatambo, at Pomahuaca. These last named remains are at a so much lower elevation, that I found the difference of level between the Inca's Road at Pomahuaca and that on the Paramo del Assuay upwards of 9100 (about 9700 English) feet. The distance in a straight line is by astronomically determined latitudes exactly 184 English geographical miles, and the ascent of the road is 3500 (3730 English) feet greater than the height of the Pass of Mount Cenis above the Lake of Como. There are two great artificial Peruvian paved roads or systems of roads, covered with flat stones, or sometimes even with cemented gravel (5) (Macadamised); one passes through the wide and arid plain between the Pacific Ocean and the chain of the Andes, and the other over the ridges of the Cordilleras. Mile-stones, or stones marking the distances, are often found placed at equal intervals. The road was conducted across rivers and deep ravines by three kinds of bridges, stone, wood, and rope bridges (Puentes de Hamaca or de Maroma), and there were also aqueducts, or arrangements for bringing water to the Tambos, (hostelries or caravanserais) and to the fortresses. Both systems of roads were directed to the central point, Cuzco, the seat of government of the great empire, in 13° 31′ South latitude, and which is placed, according to Pentland's map of Bolivia, 10676 Paris or 11378 English feet above the level of the sea. As the Peruvians employed no wheel carriages, and the roads were consequently only designed for the march of troops, for men carrying burdens, and for lightly laden lamas, we find them occasionally interrupted, on account of the steepness of the mountains, by long flights of steps, provided with resting places at suitable intervals. Francisco Pizarro and Diego Almagro, who on their distant expeditions used the military roads of the Incas with so much advantage, found great difficulties for the Spanish Cavalry at the places where these steps occurred (6). The impediment presented to their march on these occasions was so much the greater, because in the early times of the Conquista, the Spaniards used only horses instead of the carefully treading mule, who in the difficult parts of the mountains seems to deliberate on every step he takes. It was not until a later period that mules were employed.

Sarmiento, who saw the Roads of the Incas whilst they were still in a perfect state of preservation, asks in a "Relacion" which long lay unread, buried in the Library of the Escorial, "how a nation unacquainted with the use of iron could have completed such grand works in so high and rocky a region ("Caminos tan grandes y tan sovervios"), extending from Cuzco to Quito on the one hand, and to the coast of Chili on the other? The Emperor Charles," he adds, "with all his power could not accomplish even a part of what the well-ordered Government of the Incas effected through the obedient people over whom they ruled."

Hernando Pizarro, the most educated and civilised of the three brothers, who for his misdeeds suffered a twenty years' imprisonment at Medina del Campo, and died at last at a hundred years of age "in the odour of sanctity," "en olor de Santidad," exclaims: "in the whole of Christendom there are nowhere such fine roads as those which we here admire." The two important capitals and seats of government of the Incas, Çuzco and Quito, are 1000 English geographical miles apart in a straight line (SS.E., NN.W.), without reckoning the many windings of the way; and including the windings, the distance is estimated by Garcilaso de la Vega and other Conquistadores at "500 leguas." Notwithstanding the great distance, we learn from the well-confirmed testimony of the Licentiate Polo de Ondegardo, that Huayna Capac, whose father had conquered Quito, caused some of the building materials for the "princely buildings," (the houses of the Incas) in the latter city, to be brought from Cuzco.

When enterprising races inhabit a land where the form of the ground presents to them difficulties on a grand scale which they may encounter and overcome, this contest with nature becomes a means of increasing their strength and power as well as their courage. Under the despotic centralizing system of the Inca-rule, security and rapidity of communication, especially in the movement of troops, became an important necessity of government. Hence the construction of artificial roads on so grand a scale, and hence also the establishment of a highly improved postal system. Among nations in very different stages of cultivation we see the national activity display itself with peculiar predilection in some particular directions, but we can by no means determine the general state of culture of a people from the striking development of such particular and partial activity. Egyptians, Greeks (7), Etruscans, and Romans, Chinese, Japanese, and Hindoos, shew many interesting contrasts in these respects. It is difficult to pronounce what length of time may have been required for the execution of the Peruvian roads. The great works in the northern part of the Empire of the Incas, in the highlands of Quito, must at all events have been completed in less than 30 or 35 years; *i. e.* within the short period intervening between the defeat of the Ruler of "Quitu" and the death of Huayna Capac, but entire obscurity prevails as to the period of the formation of the Southern, and more properly speaking Peruvian, roads.

The mysterious appearance of Manco Capac is usually placed 400 years before the landing of Pizarro in the Island of Puna (1532), therefore towards the middle of the 12th century, almost 200 years before the foundation of the city of Mexico (Tenochtitlan); some Spanish writers even reckon, instead of 400, 500 and 550 years between Manco Capac and Pizarro. But the history of the empire of Peru only recognises thirteen ruling princes of the Inca-dynasty, a number which, as Prescott very justly remarks, is not sufficient to occupy so long an interval as 550 or even 400 years. Quetzalcoatl, Botschica, and Manco Capac, are the three mythical forms with which the commencements of civilisation among the Aztecs, the Muyscas (more properly Chibchas), and the Peruvians, are connected. Quetzalcoatl, bearded, clothed in black, a high priest of Tula, subsequently a penance-performing anchorite on a mountain near Tlaxapuchicalco, comes to the highlands of Mexico from the coast of Panuco; therefore from the eastern coast of Anahuac. Botschica, or rather Nemterequeteba (8) (a Buddha of the Muyscas), a messenger sent by the Deity, bearded and wearing long garments, arrives in the high plains of Bogota from the grassy steppes east of the chain of the Andes. Before Manco Capac a degree of civilisation already prevailed on the picturesque shores of the Lake of Titicaca. The strong fort of Cuzco, on the hill of Sacsahuaman, was formed on the pattern of the older constructions of Tiahuanaco. In the same manner the Aztecs imitated the pyramidal structures of the Toltecs, and these, those of the Olmecs (Hulmecs); and gradually ascending, we arrive, still on historic ground in Mexico, as far back as the sixth century of our Era. According to Siguenza, the Toltec step-pyramid (or Teocalli) of Cholula is a repetition of the form of the Hulmec step-pyramid of Teotihuacan. Thus as we penetrate through each successive stratum of civilisation we arrive at an earlier one; and national self-consciousness not having awoke simultaneously in the two continents, we find in each nation the imaginative mythical domain always immediately preceding the period of historic knowledge.

Notwithstanding the tribute of admiration which the first Conquistadores paid to the roads and aqueducts of the Peruvians, not only did they neglect the repair and preservation of both these classes of useful works, but they even wantonly destroyed them; and this still more towards the sea-coast, (for the sake of obtaining fine cut stones for new buildings; and where the want of water consequent on the destruction of the aqueducts has rendered the soil barren), than on the ridges of the Andes, or in the deep-cleft valleys by which the mountain chain is intersected. In the long day's journey from the syenitic rocks of Zaulaca to the Valley of San Felipe (rich in fossils, and situated at the foot of the icy Paramo de Yamoca), we were obliged to wade through the Rio de Guancabamba (which flows into the Amazons), no less than twenty-seven times, on account of the windings of the stream; while we continually saw near us, running in a straight line along the side of a steep precipice, the remains of the high built road of the Incas with its Tambos. The mountain torrent, though only from 120 to 150 English feet broad, was so strong and rapid that, in fording it, our heavily laden mules were often in danger of being swept away by the flood. They carried our manuscripts, our dried plants, and all that we had been collecting for a year past. Under such circumstances one watches from the other side of the stream with very anxious suspense until the long train of eighteen or twenty beasts of burden have passed in safety.

The same Rio de Guancabamba, in the lower part of its course, where it has many falls and rapids, is made to serve in a very singular manner for the conveyance of correspondence with the coast of the Pacific. In order to expedite more quickly the few letters from Truxillo which are intended for the province of Jaen de Bracamoros, a "swimming courier," "el correo que nada," as he is called in the country, is employed. This post messenger, who is usually a young Indian, swims in two days from Pomahuaca to Tomependa, first by the Rio de Chamaya (the name given to the lower part of the Rio de Guancabamba), and then by the Amazons. He carefully places the few letters entrusted to him in a large cotton handkerchief, which he winds round his head in the manner of a turban. When he comes to waterfalls he leaves the river, and makes a circuit through the woods. In order to lessen the fatigue of swimming for so long a time, he sometimes throws one arm round a piece of a very light kind of wood (Ceiba, Palo de balsa), of a tree belonging to the family of Bombaceæ. Sometimes also a friend goes with him to bear him company. The pair have no concern about provisions, as they are always sure of a hospitable reception in any of the scattered huts, which are abundantly surrounded with fruit trees, in the beautiful Huertas de Pucara and Cavico.

Happily the river is free from crocodiles, which, in the upper part of the Amazons, are first met with below the cataracts of Mayasi. These unwieldy and slothful monsters generally prefer the more tranquil waters. According to my measurements the Rio de Chamaya, from the Ford (Paso) de Pucara to the place where it enters the Amazons River below the village of Choros, has a fall (9) of 1668 (1778 English) feet in the short space of 52 English geographical miles. The Governor of the province of Jaen de Bracamoros assured me that letters carried by this singular water-post were rarely either wetted or lost. Soon after my return to Europe from Mexico, I received, in Paris, letters from Tomependa, which had been sent in the manner above described. Several tribes of wild Indians, living on the banks of the Upper Amazons, make their journeys in a similar manner, swimming down the stream sociably in parties. I had the opportunity of seeing in this manner, in the bed of the river, the heads of thirty or forty persons (men, women, and children), of the tribe of the Xibaros, on their arrival at Tomependa. The "Correo que nada" returns by land by the difficult route of the Paramo del Paredon.

On approaching the hot climate of the basin of the Amazons, the eye is cheered by the aspect of a beautiful, and occasionally very luxuriant vegetation. We had never before, not even in the Canaries or on the hot sea coast of Cumana and Caraccas, seen finer orange trees than those of the Huertas de Pucara. They were principally the sweet orange (Citrus aurantium, Risso), and less frequently the bitter or Seville orange (C. vulgaris, Risso). Laden with many thousands of their golden fruits, they attain a height of sixty or sixty-four English feet; and, instead of rounded tops or crowns, have aspiring branches, almost like a laurel or bay tree. Not far from thence, near the Ford of Cavico, we were surprised by a very unexpected sight. We saw a grove of small trees, only about eighteen or nineteen English feet high, which, instead of green, had apparently perfectly red or rose-coloured leaves. It was a new species of Bougainvillæa, a genus first established by the elder Jussieu, from a Brazilian specimen in Commerson's herbarium. The trees were almost entirely without true leaves, as what we took for leaves at a distance, proved to be thickly crowded bracteas. The appearance was altogether different, in the purity and freshness of the colour, from the autumnal tints which, in many of our forest trees, adorn the woods of the temperate zone at the season of the fall of the leaf. A single species of the South African family of Proteaceæ, Rhopala ferruginea, descends here from the cold heights of the Paramo de Yamoca to the hot plain of Chamaya. We often found here the Porlieria hygrometrica (belonging to the Zygophylleæ), which, by the closing of the leaflets of its finely pinnated foliage, foretels an impending change of weather, and especially the approach of rain, much better than any of the Mimosaceæ. It very rarely deceived us.

We found at Chamaya rafts (balsas) in readiness to convey us to Tomependa, which we desired to visit for the purpose of determining the difference of longitude between Quito and the mouth of the Chinchipe (a determination of some importance to the geography of South America on account of an old observation of La Condamine). (10) We slept as usual under the open sky on the sandy shore (Playa de Guayanchi) at the confluence of the Rio de Chamaya with the Amazons. The next day we embarked on the latter river, and descended it to the Cataracts and Narrows (Pongo in the Quichua language, from puncu, door or gate) of Rentema, where rocks of coarse-grained sandstone (conglomerate) rise like towers, and form a rocky dam across the river. I measured a base line on the flat and sandy shore, and found that at Tomependa the afterwards mighty River of the Amazons is only a little above 1386 English feet across. In the celebrated River Narrow or Pongo of Manseritche, between Santiago and San Borja, in a mountain ravine where at some points the overhanging rocks and the canopy of foliage forbid more than a very feeble light to penetrate, and where all the drift wood, consisting of a countless number of trunks of trees, is broken and dashed in pieces, the breadth of the stream is under 160 English feet. The rocks by which all these Pongos or Narrows are formed undergo many changes in the course of centuries. Thus a part of the rocks forming the Pongo de Rentema, spoken of above, had been broken up by a high flood a year before my journey; and there has even been preserved among the inhabitants, by tradition, a lively recollection of the precipitous fall of the then towering masses of rock along the whole of the Pongo,—an event which took place in the early part of the eighteenth century. This fall, and the consequent blocking up of the channel, arrested the flow of the stream; and the inhabitants of the village of Puyaya, situated below the Pongo de Rentema, saw with alarm the wide river-bed entirely dry: but after a few hours the waters again forced their way. Earthquake movements are not supposed to have occasioned this remarkable occurrence. The powerful stream appears to be as it were incessantly engaged in improving its bed, and some idea of the force which it exerts may be formed from the circumstance, that notwithstanding its breadth it is sometimes so swollen as to rise more than 26 English feet in the course of twenty or thirty hours.

We remained for seventeen days in the hot valley of the Upper Marañon or Amazons. In order to pass from thence to the shores of the Pacific, the Andes have to be crossed at the point where, between Micuipampa and Caxamarca (in 6° 57′ S. lat. and 78° 34′ W. long. from Greenwich), they are intersected, according to my observations, by the magnetic equator. Ascending to a still higher elevation among the mountains, the celebrated silver mines of Chota are reached, and from thence with a few interruptions the route descends until the low grounds of Peru are gained; passing intermediately over the ancient Caxamarca, where 316 years ago the most sanguinary drama in the annals of the Spanish Conquista took place, and also over Aroma and Gangamarca. Here, as almost everywhere in the Chain of the Andes and in the Mexican Mountains, the most elevated parts are picturesquely marked by tower-like outbreaks of porphyry (often columnar), and trachyte. Masses of this kind give to the crest of the mountains sometimes a cliff-like and precipitous, and sometimes a dome-shaped character. They have here broken through calcareous rocks, which, both on this and on the northern side of the equator, are largely developed; and which, according to Leopold von Buch's researches, belong to the cretaceous group. Between Guambos and Montan, 12000 French (12790 English) feet above the sea, we found marine fossils (11) (Ammonites nearly fifteen English inches in diameter, the large Pecten alatus, oyster shells, Echini, Isocardias, and Exogyra polygona). A species of Cidaris, which, according to Leopold von Buch, cannot be distinguished from that which Brongniart found in the lower part of the chalk series at the Perte du Rhone, was collected by us, both at Tomependa in the basin of the Amazons and at Micuipampa,—stations of which the elevations differ 9900 (10551 English) feet. In a similar manner, in the Amuieh Chain of the Caucasian Daghestan, the cretaceous beds rise from the banks of the Sulak, which are hardly 530 English feet above the sea, to a height of fully 9000 (9592 English) feet on the Tschunum; while on the summit of the Schadagh Mountain, 13090 (13950 English) feet high, the Ostrea diluviana (Goldf.) and the same cretaceous beds are again found. Abich's excellent observations in the Caucasus would thus appear to have confirmed in the most brilliant manner Leopold von Buch's geological views on the mountain development of the cretaceous group.

From the lonely grazing farm of Montan surrounded by herds of lamas, we ascended more to the south the eastern declivity of the Cordilleras, and arrived as night was closing in at an elevated plain where the argentiferous mountain of Gualgayoc, the principal site of the celebrated silver mines of Chota, afforded us a remarkable spectacle. The Cerro de Gualgayoc, separated by a deep-cleft ravine or valley (Quebrada) from the limestone mountain of Cormolatsche, is an isolated mass of siliceous rock traversed by a multitude of veins of silver which often meet or intersect, and terminated to the north and west by a deep and almost perpendicular precipice. The highest workings are 1445 (1540 English) feet above the floor of the gallery, the Socabon de Espinachi. The outline of the mountain is broken by numerous tower-like and pyramidal points; the summit bears indeed the name of "Las Puntas," and offers the most decided contrast to the "rounded outlines" which the miners are accustomed to attribute to metalliferous districts generally. "Our mountain," said a rich possessor of mines with whom we had arrived, "stands there like an enchanted castle (como si fuese un castillo encantado)." The Gualgayoc reminds the beholder in some degree of a cone of dolomite, but still more of the serrated crest of the Monserrat Mountains in Catalonia, which I have also visited, and which were subsequently described in so pleasing a manner by my brother. The silver mountain Gualgayoc, besides being perforated to its summit by many hundred galleries driven in every direction, presents also natural openings in the mass of the siliceous rock, through which the intensely dark blue sky of these elevated regions is visible to a spectator standing at the foot of the mountain. These openings are popularly called "windows," "las ventanillas de Gualgayoc." Similar "windows" were pointed out to us in the trachytic walls of the volcano of Pichincha, and called by a similar name,—"ventanillas de Pichincha." The strangeness of the view presented to us was still farther increased by the numerous small sheds and dwelling-houses, which nestled on the side of the fortress-like mountain wherever a flat surface permitted their erection. The miners carry down the ore in baskets by very steep and dangerous paths to the places where the process of amalgamation is performed.

The value of the silver furnished by the mines in the first thirty years (from 1771 to 1802) amounted probably to considerably above thirty-two millions of piastres. Notwithstanding the hardness of the quartzose rock, the Peruvians, before the arrival of the Spaniards (as ancient galleries and excavations testify), extracted rich argentiferous galena on the Cerro de la Lin and on the Chupiquiyacu, and gold in Curumayo (where native sulphur is also found in the quartz rock as well as in the Brazilian Itacolumite). We inhabited near the mines the small mountain town of Micuipampa, which is 11140 (11873 English) feet above the level of the sea, and where, though only 6° 43′ from the equator, water freezes in the house nightly throughout a large portion of the year. In this desert devoid of vegetation live three or four thousand persons, who are obliged to have all their means of subsistence brought from the warm valleys, as they themselves only rear some kinds of kale and excellent salad. In this wilderness, as in every town in the high mountains of Peru, ennui leads the richer class of persons, who are not on that account more cultivated or more civilised, to pass their time in deep gambling: thus wealth quickly won is still more quickly dissipated. There is much that reminds one of the soldier of Pizarro's troop, who, after the pillage of the temple at Cuzco, complained that he had lost in one night at play "a great piece of the sun" (a gold plate). I observed the thermometer at Micuipampa at 8 in the morning 1°, and at noon 7° Reaumur (34°.2 and 47°.8 Fahrenheit). We found among the thin blades of Ichhu-grass (perhaps our Stipa eriostachya), a beautiful Calceolaria (C. sibthorpioides), which we should not have expected at such an elevation.

Not far from the town of Micuipampa, in a high plain called Llanos or Pampa de Navar, there have been found throughout an area of above an English geographical square mile, immediately under the turf, and as it were intertwined with the roots of the alpine grasses, enormous masses of rich red silver ore and threads of pure silver (in remolinos, clavos, and vetas manteadas). Another elevated plain west of the Purgatorio, near the Quebrada de Chiquera, is called "Choropampa" or the "Field of Shells" (*churu*, in the Quichua language, signifies shells, and particularly small eatable kinds, *hostion, mexillon*). The name refers to fossils which belong to the cretaceous group, and which are found there in such abundance that they early attracted the attention of the natives. This is the place where there was obtained near the surface a mass of pure gold spun round with threads of silver in the richest manner. Such an occurrence shows how independent many of the ores thrown up from the interior of the earth into fissures or veins, are of the nature of the adjacent rock and of the relative age of the formations broken through. The rock of the Cerro de Gualgayoc and of Fuentestiana has a great deal of water, but in the Purgatorio absolute dryness prevails. I found to my astonishment that notwithstanding the height of the strata above the level of the sea, the temperature of the last named mine was 15°.8 Reaumur (67°.4 Fahr.); while in the neighbouring Mina de Guadalupe the water in the mine showed about 9° Reaumur (52°.2 Fahr.) As in the open air the thermometer only rises to about 4° Reaumur (41° Fahr.), the miners, whose toil is severe, and who are almost without clothing, call the subterranean heat in the Purgatorio stifling.

The narrow path from Micuipampa to the ancient city of the Incas, Caxamarca, is difficult even for mules. The name of the town was originally Cassamarca or Kazamarca, *i. e.* the Frost town; (*marca*, as signifying a place or locality, belongs to the northern Chinchaysuyo or Chinchaysuyu dialect, while the word in the general Quichua language signifies the stories of houses, and also defences or forts). Our way lay for five or six hours over a succession of Paramos, where we were exposed almost incessantly to the fury of the wind and to the sharp-edged hail so peculiar to the ridges of the Andes. The height of the route above the level of the sea is generally between nine and ten thousand feet (about 9600 and 10660 Eng.) It afforded me, however, the opportunity of making a magnetic observation of general interest; *i. e.* the determination of the point where the North Inclination of the Needle passes into South Inclination, or where the traveller's route crosses the Magnetic Equator. ([12])

On reaching at length the last of these mountain wildernesses, the Paramo de Yanaguanga, the traveller looks down with increased pleasure on the fertile valley of Caxamarca. It affords a charming prospect: a small river winds through the elevated plain, which is of an oval form and about six or seven German geographical square miles in extent (96 or 112 English geographical square miles). The plain resembles that of Bogota: both are probably the bottoms of ancient lakes; but at Caxamarca there is wanting the myth of the wonder-working Botschica or Idacanzas, the high priest of Iraca, who opened for the waters a passage through the rock of Tequendama. Caxamarca is situated 600 (640 Eng.) feet higher than Santa Fé de Bogota, therefore almost as high as the city of Quito; but being sheltered by surrounding mountains it enjoys a far milder and more agreeable climate. The soil is extremely fertile, and the plain full of cultivated fields and gardens traversed by avenues of Willows, large flowered red, white, and yellow varieties of Datura, Mimosas, and the beautiful Quinuar-trees (our Polylepsis villosa, a Rosacea allied to Alchemilla and Sanguisorba). Wheat yields on an average in the Pampa de Caxamarca fifteen to twentyfold, but the hopes of a plentiful harvest are sometimes disappointed by night frosts, occasioned by the great radiation of heat towards the unclouded sky through the dry and rarefied mountain air: the frosts are not felt in the roofed houses.

In the northern part of the plain, small porphyritic domes break through the widely extended sandstone strata, and probably once formed islands in the ancient lake before its waters had flowed off. On the summit of one of these domes, the Cerro de Santa Polonia, we enjoyed a pleasing prospect. The ancient residence of Atuhuallpa is surrounded on this side by fruit gardens and by irrigated fields of lucerne (Medicago sativa, "campos de alfalfa"). Columns of smoke are seen at a distance rising from the warm baths of Pultamarca, which are still called Baños del Inca. I found the temperature of these sulphur-springs 55°.2 Reaumur (156°.2 Fahrenheit). Atahuallpa spent a part of the year at these baths, where some slight remains of his palace still survive the devastating rage of the Conquistadores. The large and deep basin or reservoir in which, according to tradition, one of the golden chairs in which the Inca was carried had been sunk and has ever since been sought in vain, appeared to me, from the regularity of its circular shape, to have been artificially excavated in the sandstone rock above one of the fissures through which the springs issue.

Of the fort and palace of Atahuallpa there are also only very slight remains in the town, which is now adorned with some fine churches. The destruction of the ancient buildings has been accelerated by the devouring thirst of gold which led men, before the close of the sixteenth century, in digging for supposed hidden treasures, to overturn walls and carelessly to undermine or weaken the foundations of all the houses. The palace of the Inca was situated on a hill of porphyry which had originally been hollowed at the surface, so that it surrounds the principal dwelling almost like a wall or rampart. A state prison and a municipal building (la Casa del Cabildo) have been erected on a part of the ruins. The most considerable ruins still visible, but which are only from 13 to 16 feet high, are opposite the convent of San Francisco; they consist, as may be observed in the house of the Cacique, of fine cut blocks of stone two or three feet long, and placed upon each other without cement, as in the Inca-Pilca or strong fortress of Cañar in the high land of Quito.

There is a shaft sunk in the porphyritic rock which once led into subterranean chambers, and a gallery said to extend to the other porphyritic dome before spoken of, that of Santa Polonia. Such arrangements shew an apprehension of the uncertainties of war, and the desire to secure the means of escape. The burying of treasures was an old and very generally prevailing Peruvian custom. There may still be found subterranean chambers below many of the private dwellings of Caxamarca.

We were shown steps cut in the rock, and also what is called the Inca's foot-bath (el lavatorio de los pies). The washing of the monarch's feet was accompanied by some inconvenient usages of court etiquette. (13) Minor buildings, designed according to tradition for the servants, are constructed partly like the others of cut stones, and provided with sloped roofs, and partly with well formed bricks alternating with siliceous cement (muros y obra de tapia). In the latter class of constructions there are vaulted recesses, the antiquity of which I long doubted, but, as I now believe, without sufficient grounds.

In the principal building the room is still shown in which the unhappy Atahuallpa was kept a prisoner for nine months (14) from November 1532, and there is pointed out to the traveller the wall on which the captive signified to what height he would fill the room with gold if set free. This height is given very variously, by Xerez in his "Conquista del Peru" which Barcia has preserved for us, by Hernando Pizarro in his letters, and by other writers of the period. The prince said that "gold in bars, plates, and vessels, should be heaped up as high as he could reach with his hand." Xerez assigns to the room a length of 23, and a breadth of 18 English feet. Garcilaso de la Vega, who quitted Peru in his 20th year, in 1560, estimates the value of the treasure collected from the temples of the sun at Cuzco, Huaylas, Huamachuco, and Pachacamac, up to the fateful 29th of August 1553, on which day the Inca was put to death, at 3,838,000 Ducados de Oro (15).

In the chapel of the state prison, to which I have before alluded as built upon the ruins of the Inca's palace, the stone still marked by the indelible stains of blood is shown to the credulous. It is a very thin slab, 13 feet long, placed in front of the altar, and has probably been taken from the porphyry or trachyte of the vicinity. One is not permitted to make any more precise examination by striking off a part of the stone, but the three or four supposed blood spots appear to be natural collections of hornblende or pyroxide in the rock. The Licentiate Fernando Montesinos, who visited Peru scarcely a hundred years after the taking of Caxamarca, even at that early period gave currency to the fable that Atahuallpa was beheaded in prison, and that stains of blood were still visible on the stone on which the execution had taken place. There is no reason to doubt the fact, confirmed by many eye-witnesses, that the Inca, in order to avoid being burnt alive, consented to be baptised under the name of Juan de Atahuallpa by his fanatic persecutor, the Dominican monk Vicente de Valverde. He was put to death by strangulation (el garrote) publicly, and in the open air. Another tradition relates that a chapel was raised over the spot where Atahuallpa was strangled, and that his body rests beneath the stone; in such case, however, the supposed spots of blood would remain unaccounted for. In reality, however, the corpse was never placed beneath the stone in question. After a mass for the dead, and solemn funereal rites, at which the brothers Pizarro were present in mourning habits (!), it was conveyed first to the churchyard of the convent of San Francisco, and afterwards to Quito, Atahuallpa's birthplace. This last transfer was in compliance with the expressed wish of the dying Inca. His personal enemy, the astute Ruminavi ("stone-eye," a name given from the disfigurement of one eye by a wart; "rumi," signifying "stone," and "ñaui," "eye," in the Quichua language), from political motives caused the body to be buried at Quito with solemn obsequies.

We found descendants of the monarch, the family of the Indian Cacique Astorpilco, dwelling in Caxamarca, among the melancholy ruins of ancient departed splendour, and living in great poverty and privation; but patient and uncomplaining. Their descent from Atahuallpa through the female line has never been doubted in Caxamarca, but traces of beard may perhaps indicate some admixture of Spanish blood. Of the sons of the Great (but for a child of the sun somewhat free thinking), (16) Huayna Capac, neither of the two who swayed the sceptre before the arrival of the Spaniards, Huascar and Atahuallpa, left behind them acknowledged sons. Huascar became the prisoner of Atahuallpa in the plains of Quipaypan, and was soon afterwards secretly murdered by his order. Neither were there any surviving male descendants of the two remaining brothers of Atahuallpa, the insignificant youth Toparca, who Pizarro caused to be crowned as Inca in the autumn of 1553, and the enterprising Manco Capac, similarly crowned, but who afterwards rebelled again. Atahuallpa left indeed a son, whose christian name was Don Francisco, (but who died very young), and a daughter, Doña Angelina, by whom Francisco Pizarro (with whom she led a wild and warlike life), had a son whom he loved fondly, grandchild of the slaughtered monarch. Besides the family of the Cacique Astorpilco, with whom I was acquainted at Caxamarca, the Carguraicos and Titu Buseamayta were pointed out at the period of my visit as belonging to the Inca dynasty; but the Buseamayta family has since become extinct.

The son of the Cacique Astorpilco, a pleasing and friendly youth of seventeen, who accompanied me over the ruins of the palace of his ancestor, while living in extreme poverty, had filled his imagination with images of buried splendour and golden treasures hidden beneath the masses of rubbish upon which we trod. He related to me that one of his more immediate forefathers had bound his wife's eyes, and then conducted her through many labyrinths cut in the rock into the subterranean garden of the Incas. There she saw, skilfully and elaborately imitated, and formed of the purest gold, artificial trees, with leaves and fruit, and birds sitting on the branches; and there too was the much sought for golden travelling chair (una de las andas) of Atahuallpa. The man commanded his wife not to touch any of these enchanted riches, because the long foretold period of the restoration of the empire had not yet arrived, and that whoever should attempt before that time to appropriate aught of them would die that very night. These golden dreams and fancies of the youth were founded on recollections and traditions of former days. These artificial "golden gardens" (Jardines o Huertas de oro) were often described by actual eye-witnesses, Cieza de Leon Sarmiento, Garcilaso, and other early historians of the Conquest. They were found beneath the temple of the sun at Cuzco, in Caxamarca, and in the pleasant valley of Yucay, a favourite residence of the monarch's family. Where the golden Huertas were not below ground, living plants grew by the side of the artificial ones: among the latter, tall plants and ears of maize (mazorcas) are mentioned as particularly well executed.

The morbid confidence with which the young Astorpilco assured me that below our feet, a little to the right of the spot on which I stood at the moment, there was an artificial large-flowered Datura tree (Guanto), formed of gold wire and gold plates, which spread its branches over the Inca's chair, impressed me deeply but painfully, for it seemed as if these illusive and baseless visions were cherished as consolations in present sufferings. I asked the lad—"Since you and your parents believe so firmly in the existence of this garden, are not you sometimes tempted in your necessities to dig in search of treasures so close at hand?" The boy's answer was so simple, and expressed so fully the quiet resignation characteristic of the aboriginal inhabitants of the country, that I noted it in Spanish in my journal. "Such a desire (tal antojo) does not come to us; father says it would be sinful (que fuese pecado). If we had the golden branches with all their golden fruits our white neighbours would hate and injure us. We have a small field and good wheat (buen trigo)." Few of my readers, I think, will blame me for recalling here the words of the young Astorpilco and his golden visions.

The belief, so widely current among the natives, that to take possession of buried treasures which belonged to the Incas would be wrong, and would incur punishment and bring misfortune on the entire race, is connected with another belief which prevailed, especially in the 16th and 17th centuries, *i. e.* the future restoration of a kingdom of the Incas. Every suppressed nationality looks forward to a day of change, and to a renewal of the old government. The flight of Manco Inca, the brother of Atahuallpa, into the forests of Vilcapampa on the declivity of the eastern Cordillera, and the sojourn of Sayri Tupac and Inca Tupac Amaru in those wildernesses, have left permanent recollections. It was believed that the dethroned dynasty had settled between the rivers Apurimac and Beni, or still farther to the east in Guiana. The myth of el Dorado and the golden city of Manoa, travelling from the west to the east, increased these dreams, and Raleigh's imagination was so inflamed by them, that he founded an expedition on the hope of "conquering 'the imperial and golden city,' placing in it a garrison of three or four thousand English, and levying from the 'Emperor of Guiana,' a descendant of Huayna Capac, and who holds his court with the same magnificence, an annual tribute of £300,000 sterling, as the price of his promised restoration to the throne in Cuzco and Caxamarca." Wherever the Peruvian Quichua language has extended, some traces of such expectations of the return of the Inca's sovereignty continue ([17]) to exist in the minds of many among those of the natives who are possessed of some knowledge of the history of their country.

We remained for five days in the town of the Inca Atahuallpa, which at that time scarcely reckoned seven or eight thousand inhabitants. Our departure was delayed by the number of mules which were required for the conveyance of our collections, and by the necessity of making a careful choice of the guides who were to conduct us across the chain of the Andes to the entrance of the long but narrow Peruvian sandy desert (Desierto de Sechura). The passage over the Cordillera is from north-east to south-west. Immediately after quitting the plain of Caxamarca, on ascending a height of scarcely 9600 (10230 English) feet, the traveller is struck with the sight of two grotesquely shaped porphyritic summits, Aroma and Cunturcaga (a favourite haunt of the powerful vulture which we commonly call Condor; *kacca* in the Quichua language signifies "the rock.") These summits consisted of five, six, or seven-sided columns, 37 to 42 English feet high, and some of them jointed. The Cerro Aroma is particularly picturesque. By the distribution of its often converging series of columns placed one above another, it resembles a two-storied building, which, moreover, is surmounted by a dome or cupola of non-columnar rock. Such outbursts of porphyry and trachyte are, as I have before remarked, characteristic of the high crests of the Cordilleras, to which they impart a physiognomy quite distinct from that presented by the Swiss Alps, the Pyrenees, and the Siberian Altai.

From Cunturcaga and Aroma we descended by a zig-zag course a steep rocky declivity of 6400 English feet into the deep cleft valley of the Magdalena, the bottom of which is still 4260 English feet above the level of the sea. A few wretched huts, surrounded by the same wool or cotton-trees (Bombax discolor) which we had first seen on the banks of the Amazons, were called an Indian village. The scanty vegetation of the valley bears some resemblance to that of the province of Jaen de Bracamoros, but we missed the red groves of Bougainvillæa. This valley is one of the deepest with which I am acquainted in the chain of the Andes: it is a true transverse valley directed from east to west, deeply cleft, and hemmed in on the two sides by the Altos de Aroma and Guangamarca. In this valley recommences the same quartz formation which we had observed in the Paramo de Yanaguanga, between Micuipampa and Caxamarca, at an elevation of 11720 English feet, and which, on the western declivity of the Cordillera, attains a thickness of several thousand feet, and was long an enigma to me. Since von Buch has shown us that the cretaceous group is also widely extended in the highest chains of the Andes, on either side of the Isthmus of Panama, the quartz formation which we are now considering, which has perhaps been altered in its texture by the action of volcanic forces, may be considered to belong to the Quadersandstein, intermediate between the upper part of the chalk series, and the Gault and Greensand. On quitting the mild temperature of the Magdalena valley we had to ascend again for three hours the mountain wall of 5120 English feet, opposite to the porphyritic group of the Alto de Aroma. The change of climate in so doing was the more sensible, as we were often enveloped in the course of the ascent in a cold fog.

The longing desire which we felt to enjoy once more the open view of the sea after eighteen months' constant sojourn in the ever restricted range of the interior of the mountains, had been heightened by repeated disappointments. In looking from the summit of the volcano of Pichincha, over the dense forests of the Provincia de las Esmeraldas, no sea horizon can be clearly distinguished, by reason of the too great distance of the coast and height of the station: it is like looking down from an air-balloon into vacancy. One divines, but one does not distinguish. Subsequently, when between Loxa and Guancabamba we reached the Paramo de Guamini, where there are several ruined buildings of the times of the Incas, and from whence the mule-drivers had confidently assured us that we should see beyond the plain, beyond the low districts of Piura and Lambajeque, the sea itself which we so much desired to behold, a thick mist covered both the plain and the distant sea shore. We saw only variously shaped masses of rock alternately rise like islands above the waving sea of mist, and again disappear, as had been the case in our view from the Peak of Teneriffe. We were exposed to almost the same disappointment in our subsequent transit over the pass of Guangamarca, at the time of which I am now speaking. As we toiled up the mighty mountain side, with our expectations continually on the stretch, our guides, who were not perfectly acquainted with the road, repeatedly promised us that at the end of the hour's march which was nearly concluded, our hopes would be realised. The stratum of mist which enveloped us appeared occasionally to be about to disperse, but at such moments our field of view was again restricted by intervening heights.

The desire which we feel to behold certain objects does not depend solely on their grandeur, their beauty, or their importance; it is interwoven in each individual with many accidental impressions of his youth, with early predilection for particular occupations, with an attachment to the remote and distant, and with the love of an active and varied life. The previous improbability of the fulfilment of a wish gives besides to its realisation a peculiar kind of charm. The traveller enjoys by anticipation the first sight of the constellation of the cross, and of the Magellanic clouds circling round the Southern Pole,—of the snow of the Chimborazo, and the column of smoke ascending from the volcano of Quito,—of the first grove of tree-ferns, and of the Pacific Ocean. The days on which such wishes are realised form epochs in life, and produce ineffaceable impressions; exciting feelings of which the vividness seeks not justification by processes of reasoning. With the longing which I felt for the first view of the Pacific from the crests of the Andes, there mingled the interest with which I had listened as a boy to the narrative of the adventurous expedition of Vasco Nuñez de Balboa, (18) the fortunate man who (followed by Francisco Pizarro) first among Europeans beheld from the heights of Quarequa, on the Isthmus of Panama, the eastern part of the Pacific Ocean,—the "South Sea." The reedy shores of the Caspian, at the place where I first saw them, *i. e.* from the Delta formed by the mouths of the Volga, cannot certainly be called picturesque; yet I viewed them with a gratification heightened almost into delight by the particular interest and pleasure with which, in early childhood, I had looked at the shape of this Asiatic inland sea on maps. That which is thus excited in us (19) by childish impressions, or by accidental circumstances in life, takes at a later period a graver direction, and often becomes a motive for scientific labours and distant enterprises.

When after many undulations of the ground, on the summit of the steep mountain ridge, we finally reached the highest point, the Alto de Guangamarca, the heavens which had long been veiled became suddenly clear: a sharp west wind dispersed the mist, and the deep blue of the sky in the thin mountain air appeared between narrow lines of the highest cirrous clouds. The whole of the western declivity of the Cordillera by Chorillos and Caseas, covered with large blocks of quartz 13 to 15 English feet long, and the plains of Chala and Molinos as far as the sea shore near Truxillo, lay beneath our eyes in astonishing apparent proximity. We now saw for the first time the Pacific Ocean itself; and we saw it clearly: forming along the line of the shore a large mass from which the light shone reflected, and rising in its immensity to the well-defined, no longer merely conjectured horizon. The joy it inspired, and which was vividly shared by my companions Bonpland and Carlos Montufar, made us forget to open the barometer until we had quitted the Alto de Guangamarca. From our measurement taken soon after, but somewhat lower down, at an isolated cattle-farm called the Hato de Guangamarca, the point from which we first saw the sea would be only somewhere between 9380 and 9600 English feet above the level of the sea.

The view of the Pacific was peculiarly impressive to one who like myself owed a part of the formation of his mind and character, and many of the directions which his wishes had assumed, to intercourse with one of the companions of Cook. My schemes of travel were early made known, in their leading outlines at least, to George Forster, when I enjoyed the advantage of making my first visit to England under his guidance, more than half a century ago. Forster's charming descriptions of Otaheite had awakened throughout Northern Europe a general interest (mixed, I might almost say, with romantic longings) for the Islands of the Pacific which had at that time been seen by very few Europeans. I too cherished at the time of which I am speaking the hope of soon landing on them; for the object of my visit to Lima was twofold,—to observe the transit of Mercury over the solar disk, and to fulfil an engagement made with Captain Baudin before I left Paris, to join him in a voyage of circumnavigation which was to take place as soon as the Government of the French Republic could furnish the requisite funds.

Whilst we were in the Antilles, North American newspapers announced that the two Corvettes, Le Géographe and Le Naturaliste, would sail round Cape Horn and touch at Callao de Lima. On receiving this intelligence at Havana, where I then was, after having completed my Orinoco journey, I relinquished my original plan of going through Mexico to the Philippines, and hastened to engage a vessel to convey me from the Island of Cuba to Cartagena de Indias. Baudin's Expedition, however, took quite a different route from that which was announced and expected; instead of sailing round Cape Horn, as had been designed when it had been intended that Bonpland and myself should form part of it, it sailed round the Cape of Good Hope. One of the two objects of my Peruvian journey and of our last passage over the Chain of the Andes failed; but on the other hand I had, at the critical moment, the rare good fortune of a perfectly clear day, during a very unfavourable season of the year, on the misty coast of Low Peru. I observed the passage of Mercury over the Sun at Callao, an observation which has become of some importance towards the exact determination of the longitude of Lima (20), and of all the south-western part of the New Continent. Thus in the intricate relations and graver circumstances of life, there may often be found, associated with disappointment, a germ of compensation.

ANNOTATIONS AND ADDITIONS.

(1) p. 267.—"*On the ridge of the Chain of the Andes or Antis.*"

The Inca Garcilaso, who was well acquainted with the language of his country and was fond of dwelling on etymologies, always calls the Chain of the Andes las Montañas de los Antis. He says positively, that the great Mountain chain east of Cuzco derived its name from the tribe of the Antis, and the Province of Anti which is to the east of the Capital of the Incas. The Quaternary division of the Peruvian Empire according to the four quarters of the Heavens, reckoned from Cuzco, borrowed its terminology not from the very circumstantial words taken which signify East, West, North, and South in the Quichua language (intip lluscinanpata, intip yaucunanpata, intip chaututa chayananpata, intip chaupunchau chayananpata); but from the names of the Provinces and of the tribes or races, (Provincias llamadas Anti, Cunti, Chincha y Colla), which are east, west, north, and south of the Centre of the Empire (the city of Cuzco). The four parts of the Inca-theocracy are called accordingly Antisuyu, Cuntisuyu, Chinchasuyu, and Collasuyu. The word *suyu* signifies "strip," and also "part." Notwithstanding the great distance, Quito belonged to Chinchasuyu; and in proportion as by their religious wars the Incas extended still more widely the prevalence of their faith, their language, and their absolute form of government, these Suyus also acquired larger and unequally increased dimensions. Thus the names of provinces came to be used to express the different quarters of the heavens; "Nombrar aquellos Partidos era lo mismo," says Garcilaso, "que decir al Oriente, ó al Poniente." The Snow Chain of the Antis was thus looked upon as an East chain. "La Provincia Anti da nombre á las Montañas de los Antis. Llamaron la parte á del Oriente Antisuyu, por la qual tambien llaman Anti á toda aquella gran Cordillera de Sierra Nevada que pasa al Oriente del Peru, por dar á entender, que está al Oriente." (Commentarios Reales, P. I. p. 47 and 122.) Later writers have tried to deduce the name of the Chain of the Andes from "anta," which signifies "copper" in the Quichua language. This metal was indeed of the greatest importance to a nation whose tools and cutting instruments were made not of iron but of copper mixed with tin; but the name of the "Copper Mountains" can hardly have been extended to so great a chain; and besides, as Professor Buschmann very justly remarks, the word anta retains its terminal *a* when making part of a compound word: *anta,* cobre, y *antamarca* Provincia de Cobre. Moreover, the form and composition of words in the ancient Peruvian language are so simple that there can be no question of the passage of an *a* into an *i*; and thus "anta" (copper) and "Anti or Ante" (meaning as dictionaries of the country explain "la tierra de los Andes, el Indio hombre de los Andes, la Sierra de los Andes," *i. e.* the country of the Andes, an inhabitant of the Andes, or the chain of mountains themselves), are and must continue two wholly different and distinct words. There are no means of interpreting the proper name (Anti) by connecting it with any signification or idea; if such connection exist it is buried in the obscurity of the past. Other Composites of Anti besides the above-mentioned Antisuyu are "Anteruna" (the native inhabitant of the Andes), and Anteunccuy or Antionccoy, (sickness of the Andes, mal de los Andes pestifero).

(2) p. 268.—"*The Countess of Chinchon.*"

She was the wife of the Viceroy Don Geronimo Fernandez de Cabrera, Bobadilla y Mendoza, Conde de Chinchon, who administered the government of Peru from 1629 to 1639. The cure of the Vice-Queen falls in the year 1638. A tradition which has obtained currency in Spain, but which I have heard much combated at Loxa, names a Corregidor del Cabildo de Loxa, Juan Lopez de Cañizares, as the person by whom the Quina-bark was first brought to Lima and generally recommended as a remedy. I have heard it asserted in Loxa that the beneficial virtues of the tree were known long before in the mountains, though not generally. Immediately after my return to Europe I expressed the doubts I felt as to the discovery having been made by the natives of the country round Loxa, since even at the present day the Indians of the neighbouring valleys, where intermittent fevers are very prevalent, shun the use of bark. (Compare my memoir entitled "über die Chinawälder" in the "Magazin der Gesellschaft naturforschender Freunde" zu Berlin, Jahrg. I. 1807, S. 59.) The story of the natives having learnt the virtues of the Cinchona from the lions who "cure themselves of intermittent fevers by gnawing the bark of the China (or Quina) trees,"—(Hist. de l'Acad. des Sciences, année 1738, Paris, 1740, p. 233),—appears to be entirely of European origin, and nothing but a monkish fable. Nothing is known in the New Continent of the "Lion's fever," for the large so-called American Lion (Felis concolor), and the small mountain Lion (Puma) whose footmarks I have seen on the snow, are never tamed and made the subjects of observation; nor are the different species of Felinæ in either continent accustomed to gnaw the bark of trees. The name of Countess's Powder (Pulvis Comitissæ), occasioned by the remedy having been distributed by the Countess of Chinchon, was afterwards changed to that of Cardinal's or Jesuit's powder, because Cardinal de Lugo, Procurator-General of the order of the Jesuits, spread the knowledge of this valuable remedy during a journey through France, and recommended it to Cardinal Mazarin the more urgently, as the brethren of the order were beginning to prosecute a lucrative trade in South American Quina-bark which they obtained through their missionaries. It is hardly necessary to remark, that in the long controversy which ensued respecting the good or bad effects of the fever bark, the protestant physicians sometimes permitted themselves to be influenced by religious intolerance and dislike of the Jesuits.

(3) p. 271.—"*Aposentos de Mulalos.*"

Respecting these aposentos (dwellings, inns, in the Quichua language *tampu,* whence the Spanish form tambo), compare Cieça, Chronica del Peru, cap. 41, (ed. de 1554, p. 108) and my Vues des Cordillères, Pl. xxiv.

(4) p. 272.—"*The fortress of the Cañar*"

Is situated not far from Turche, at an elevation of 9984 (10640 English) feet. I have given a drawing of it in the Vues des Cordillères, Pl. xvii. (compare also Cieça, cap. 44, P. i. p. 120). Not far from the Fortaleza del Cañar, in the celebrated ravine of the Sun, Inti-Guaycu, (in the Quichua or Qquechhua language, *huaycco*), is the rock on which the natives think they see a representation of the sun and of an enigmatical sort of bank or bench which is called Inga-Chungana (Incachuncana), the Inca's play. I have drawn both. See Vues des Cordillères, Pl. xviii. and xix.

(5) p. 272.—"*Artificial roads covered with cemented gravel.*"

Compare Velasco, Historia de Quito, 1844, T. i. p. 126-128, and Prescott, Hist. of the Conquest of Peru, Vol. i. p. 157.

(6) p. 273.—"*Where the road was interrupted by flights of steps.*"

Compare Pedro Sancho in Ramusio, Vol. iii. fol. 404, and Extracts from Manuscript Letters of Hernando Pizarro, employed by the great historical writer now living at Boston; Prescott, Vol. i. p. 444. "El camino de las sierras es cosa de ver, porque en verdad en tierra tan fragosa en la cristiandad no se han visto tan hermosos caminos, toda la mayor parte de calzada."

(7) p. 275.—"*Greeks and Romans shew these contrasts.*"

"If," says Strabo, (Lib. v. p. 235, Casaub) "the Greeks in building their cities sought for a happy result by aiming especially at beauty and solidity, the Romans on the other hand have regarded particularly, objects which the Greeks left unthought of;—stone pavements in the streets; aqueducts bringing to the city abundant supplies of water; and provisions for drainage so as to wash away and carry to the Tiber all uncleanliness. They also paved the roads through the country, so that waggons may transport with ease the goods brought by trading ships."

(8) p. 276.—"*The messenger of the deity Nemterequeteba.*"

The civilisation of ancient Mexico (the Aztec land of Anahuac), and that of the Peruvian theocracy or empire of the Incas, the children of the Sun, have so engrossed attention in Europe, that a third point of comparative light and of dawning civilisation, which existed among the nations inhabiting the mountains of New Granada, was long almost entirely overlooked. I have touched on this subject in some detail in the Vue des Cordillères et Monumens des Peuples Indigènes de l'Amérique (ed. in 8vo.) T. ii. p. 220-

267. The form of the government of the Muyscas of New Granada reminds us of the constitution of Japan and the relation of the Secular Ruler (Kubo or Seogun at Jeddo) to the sacred personage the Daïri at Miyako. When Gonzalo Ximenez de Quesada advanced to the high table land of Bogota (Bacata, *i. e.* the extremity of the cultivated fields, probably from the proximity of the mountain wall), he found there three powers or authorities respecting whose reciprocal relations and subordination there remains some uncertainty. The spiritual chief, who was appointed by election, was the high priest of Iraca or Sogamoso (Sugamuxi, the place of the disappearance of Nemterequeteba): the secular rulers or princes were the Zake (Zaque of Hunsa or Tunja), and the Zipa of Funza. In the feudal constitution the last-named prince appears to have been originally subordinate to the Zake.

The Muyscas had a regular mode of computing time, with intercalation for amending the lunar year: they used small circular plates of gold, cast of equal diameter, as money (any traces of which among the highly civilised ancient Egyptians have been sought in vain), and they had temples of the Sun with stone columns, remains of which have very recently been discovered in the Valley of Leiva. (Joaquin Acosta, Compendio historico del Descubrimiento de la Nueva Granada, 1848, p. 188, 196, 206, and 208; Bulletin de la Société de Géographie de Paris, 1847, p. 114.) The tribe or race of the Muyscas ought properly speaking to be always denoted by the name of Chibchas; as Muysca in the Chibcha language signifies merely "men," "people."

The origin and elements of the civilisation introduced are attributed to two mystical forms, Bochiea (Botsehiea) and Nemtercqucteba which are often confounded together. The first of these is still more mythical than the second; for it was only Botsehiea who was regarded as divine, and made almost equal to the Sun itself. His fair companion Chia or Huythaca occasioned by her magical arts the overflowing of the valley of Bogota, and for so doing was banished by Botsehiea from the earth, and made to revolve round it for the first time, as the moon. Botsehica struck the rock of Tequendama, and gave a passage for the waters to flow off near the field of the Giants (Campo de Gigantes) in which the bones of elephant-like mastodons lie buried at an elevation of 8250 (8792 Engl.) feet above the level of the sea. Captain Coehrane (Journal of a Residence in Colombia, 1825, Vol. ii. p. 390) and Mr. John Ranking (Historical Researches on the Conquest of Peru, 1827, p. 397), state that animals of this species are still living in the Andes, and shed their teeth! Nemtcrequeteba, also called Chinzapogua (enviado de Dios) is a human person, a bearded man, who came from the East, from Pasea, and disappeared at Sogamoso. The foundation of the sanctuary of Iraea is sometimes ascribed to him and sometimes to Botsehiea, and as the latter is said to have borne also the name of Nemqueteba, the confusion between the two, on ground so unhistoric, is easily accounted for.

My old friend Colonel Acosta, in his instructive work entitled Compendio de la Hist. de la Nueva Granada, p. 185, endeavours to prove by means of the Chibeha language that "potatoes (Solanum tuberosum) bear at Usmè the native non-Peruvian name of Yomi, and were found by Quesada already cultivated in the province of Velez as early as 1537, a period when their introduction from Chili, Peru, and Quito, would seem improbable, and therefore that the plant may be regarded as a native of New Granada." I would remark, however, that the Peruvian invasion and complete possession of Quito took place before 1525, the year of the death of the Inca Huayna Capac. The southern provinces of Quito even fell under the dominion of Tupac Inca Yupanqui at the conclusion of the 15th century (Prescott, Conquest of Peru, Vol. i. p. 332.) In the unfortunately still very obscure history of the first introduction of the potato into Europe, the merit of its introduction is still very generally attributed to Sir John Hawkins, who is supposed to have received it from Santa Fé in 1563 or 1565. It appears more certain that Sir Walter Raleigh planted the first potatoes on his Irish estate near Youghal, from whence they were taken to Lancashire. Before the conquista, the plantain (Musa), which since the arrival of the Spaniards has been cultivated in all the warmer parts of New Granada, was only found, as Colonel Acosta believes, (p. 205) at Choco. On the name Cundinamarca,—applied by a false erudition to the young republic of New Granada in 1811, a name "full of golden dreams" (sueños dorados), more properly Cundirumarca (not Cunturmarca, Garcilaso, lib. viii. cap. 2),—see also Joaquin Acosta, p. 189. Luis Daza, who joined the small invading army of the Conquistador Sebastian de Belalcazar which came from the south, had heard of a distant country abounding in gold, called

Cundirumarca, inhabited by the tribe of the Chicas, and whose prince had solicited Atahuallpa at Caxamarca for auxiliary troops. These Chicas have been confounded with the Chibchas or Muyscas of New Granada; and thus the name of the unknown more southern country has been unduly transferred to that territory.

(9) p. 278.—"*The fall of the Rio de Chamaya.*"

Compare my Recueil d'Observ. Astron., vol. i. p. 304; Nivellement barométrique, No. 236-242. I have given in the Vues des Cordillères, Pl. xxxi. a drawing of the "swimming post," as he binds round his head the handkerchief containing the letters.

(10) p. 280.—"*Which, on account of an old observation of La Condamine, was of some importance to the geography of South America.*"

I desired to connect chronometrically Tomependa, the point at which La Condamine began his voyage, and other places geographically determined by him on the Amazons river, with the town of Quito. La Condamine had been in June 1743, (59 years before me) at Tomependa, which place I found, by star observations taken for three nights, to be in south lat. 5° 31′ 28″, and west longitude from Paris 80° 56′ 37″ (from Greenwich 78° 34′ 55″). Previous to my return to France the longitude of Quito was in error to the full amount of 50½ minutes of arc, as Oltmanns has shown by my observations, and by a laborious recalculation of all those previously made. (Humboldt, Recueil d'Observations Astron., vol. ii. p. 309-359). Jupiter's satellites, lunar distances, and occultations, give a satisfactory accordance, and all the elements of the calculation are placed before the public. The too easterly longitude of Quito was transferred by La Condamine to Cuenca and the Amazons river. "Je fis," says La Condamine, "mon premier essai de navigation sur un radeau (balsa) en descendant la rivière de Chinchipe jusqu'à Tomependa. Il fallut me contenter d'en déterminer la latitude et de conclure la longitude par les routes. J'y fis mon testament politique en rédigeant l'extrait de mes observations le plus importantes." (Journal du Voyage fait à l'Equateur, 1751, p. 186.)

(11) p. 282.—"*At upwards of twelve thousand feet above the sea we found fossil marine shells.*"

See my Essai géognostique sur le Gisement des Roches, 1823, p. 236; and for the first zoological determination of the fossils contained in the cretaceous group in the chain of the Andes, see Léop. de Buch, Pétrifications recueillies en Amérique, par Alex. de Humboldt et Charles Degenhardt, 1839 (in fol.), pp. 2-3, 5, 7, 9, 11, and 18-22. Pentland found fossil shells of the Silurian formation in Bolivia, on the Nevado de Antakäua, at the height of 164000 French (17480 English) feet, (Mary Somerville, Physical Geography, 1849, Vol. i. p. 185).

(12) p. 287.—"*Where the chain of the Andes is intersected by the magnetic equator.*"

Compare my Rélation hist. du Voyage aux Régions équinoxiales, T. iii. p. 622; and Kosmos, Bd. i. S. 191

and 432; where, however, by errors of the press, the longitude is once 48° 40′, and afterwards 80° 40′, instead of, as it should be, 80° 54′ from Paris (or 78° 32′ from Greenwich), (English edit. p. 173, and note 159).

(13) p. 290.—"*Accompanied by inconvenient ceremonies of Court etiquette.*"

In conformity with a highly ancient Court ceremonial, Atahuallpa spat not on the ground, but into the hand of one of the principal ladies present; "all," says Garcilaso, "on account of his majesty." El Inca nunca escupia en el suelo, sino en la mano de una Señora mui principal, por Majestad, (Garcilaso, Comment. Reales, P. ii. p. 46).

(14) p. 290.—"*Captivity of Atahuallpa.*"

A short time before the captive Inca was put to death, he was taken into the open air, in compliance with his request, to see a large comet. The "greenish black comet, nearly as thick as a man," (Garcilaso says, P. ii. p. 44, una cometa verdinegra, poco menos gruesa que el cuerpo de un hombre), seen by Atahuallpa before his death, therefore in July or August 1533, and which he supposed to be the same malignant comet which had appeared at the death of his father, Huayna Capac, is certainly the one observed by Appian (Pingré, Cométographie, T. i. p. 496; and Galle's "Notice of all the Paths of Comets hitherto computed," in "Olber's Leichtester Methode die Bahn eines Cometen zu berechnen," 1847, S. 206), and which, on the 21st of July, standing high in the north, near the constellation of Perseus, represented the sword which Perseus holds in his right hand. (Mädler, Astronomie, 1846, S. 307; Schnurrer, Die Chronik der Seuchen in Verbindung mit gleichzeitigen Erscheinungen, 1825, Th. ii. S. 82.) Robertson considers the year of Huayna Capac's death uncertain; but, from the researches of Balboa and Velasco, that event appears to have occurred towards the close of 1525: thus the statements of Hevelius (Cometographia, p. 844), and of Pingré (T. i. p. 485), derive confirmation from the testimony of Garcilaso (P. i. p. 321) and the tradition preserved among the "amautas, que son los filosofos de aquella Republica." I may here introduce the remark, that Oviedo alone, and certainly erroneously, asserts, in the inedited continuation of his Historia de las Indias, that the proper name of the Inca was not Atahuallpa, but Atabaliva (Prescott, Conquest of Peru, Vol. i. p. 498.)

(15) p. 291.—"*Ducados de Oro.*"

The sum mentioned in the text is that which is stated by Garcilaso de la Vega in the Commentarios reales de los Incas, Parte ii. 1722, pp. 27 and 51. The statements of Padre Blas Valera and of Gomara, Historia de las Indias, 1553, p. 67, differ, however, considerably. Compare my Essai politique sur la Nouvelle Espagne (éd. 2), T. iii. p. 424). It is, moreover, no less difficult to determine the value of the Ducado, Castellano, or Peso de Oro. (Essai pol. T. iii. pp. 371 and 377; Joaquin Acosta, Descubrimiento de la Nueva Granada, 1848, p. 14.) The modern excellent historical writer, Prescott, has been able to avail himself of a manuscript bearing the very promising title, "Acta de Repartieion del Rescate de Atahuallpa." The estimate of the whole Peruvian booty which the brothers Pizarro and Almagro divided amongst themselves at the (I believe) too large value of three and a half millions of pounds sterling, includes doubtless the gold of the ransom and that taken from the different temples of the Sun and from the enchanted gardens, (Huertas de Oro). (Prescott, Conquest of Peru, Vol. i. pp. 464-477.)

(16) p. 292.—"*The great, but, for a Son of the Sun, somewhat free-thinking Huayna Capac.*"

The nightly absence of the Sun excited in the Inca many philosophical doubts as to the government of the world by that luminary. Padre Blas Valera noted down the remarks of the Inca on the subject of the Sun: "Many maintain that the Sun lives, and is the Maker and Doer of all things (el hacedor de todas las cosas); but whoever would complete any thing must remain by what he is doing. Now many things take place when the Sun is absent; therefore he is not the original cause of all things. It seems also doubtful whether he is living; for though always circling round, he is never weary (no se cansa). If he was living, he would become weary, as we do; and if he was free, he would surely move sometimes into parts of the heavens where we never see him. The Sun is like an animal fastened by a cord so as always to move in the same round, (como una Res atada que siempre hace un mismo cerco); or as an arrow which only goes where it is sent, and not where it chooses itself." (Garcilaso, Comment. Reales, P. i. lib. viii. cap. 8, p. 276.) The view taken of the circling round of a heavenly body, as if it was fastened to a cord, is very striking. As Huayna Capac died at Quito in 1525, seven years before the arrival of the Spaniards, he no doubt used, instead of "res atada," the general expression of an "animal" fastened to a cord; but indeed, even in Spanish, "res" is by no means limited to oxen, but may be applied to any tame cattle. We cannot examine here how far the Padre may have mingled parts of his own sermons with the heresies of the Inca, with the view of weaning the natives from the official and dynastic worship of the Sun, the religion of the Court. We see in the very conservative State policy, and in the maxims of State and proceedings of the Inca Roca, the conqueror of the province of Charcas, the solicitude which was felt to guard strictly the lower classes of the people from such doubts. This Inca founded schools for the upper classes only, and forbade, under heavy penalties, to teach the common people any thing, "lest they should become presumptuous, and should create disturbances in the State!" (No es lecito que enseñen á los hijos de los Plebeios las Ciencias, porque la gente baja no se eleve y ensobervezca y menoscabe la Republica; Garcilaso, P. i. p. 276.) Thus the policy of the Inca's theocracy was almost the same as that of the Slave States in the United Free States of North America.

(17) p. 295.—"*The restoration of an empire of the Incas.*"

I have treated this subject more fully in another place

(Relation hist. T. iii. p. 703-705 and 713). Raleigh thought there was in Peru an old prophecy "that from Inglaterra those Ingas should be againe in time to come restored and deliuered from the seruitude of the said conquerors. 'I am resolued that if there were but a smal army afoote in Guiana marching towards Manoa, the chiefe citie of Inga, he would yield Her Majestie by composition so many hundred thousand pounds yearely, as should both defend all enemies abroad and defray all expences at home, and that he woulde besides pay a garrison of 3000 or 4000 soldiers very royally to defend him against other nations. The Inca wil be brought to tribute with great gladnes." (Raleigh, "The Discovery of the large, rich, and beautiful Empire of Guiana, performed in 1595," according to the edition published by Sir Robert Schomburgk, 1848, p. 119 and 137.) This scheme of a Restoration promised much that might be very agreeable to both sides, but unfortunately the dynasty who were to be restored, and who were to pay the money, were wanting!

(18) p. 299.—"*Of the expedition of Vasco Nuñez de Balboa.*"

I have already remarked elsewhere (Examen critique de l'histoire de la Géographie du Nouveau Continent, et des progrès de l'Astronomie nautique aux 15ème et 16ème siècles, T. i. p. 349) that Columbus knew fully ten years before Balboa's expedition the existence of the South Sea and its great proximity to the east coast of Veragua. He was conducted to this knowledge not by theoretical speculations respecting the configuration of Eastern Asia, but by the local and positive reports of the natives, which he collected on his fourth voyage (May 11, 1502, to November 7, 1504). On this fourth voyage the Admiral went from the coast of Honduras to the Puerto de Mosquitos, the western end of the Isthmus of Panama. The reports of the natives, and the comments of Columbus on those reports in the "Carta rarissima" of the 7th of July, 1503, were to the effect that "not far from the Rio de Belen the other sea (the South Sea) turns (boxa) to the mouths of the Ganges, so that the countries of the Aurea (*i. e.* the countries of the Chersonesus aurea of Ptolemy) are situated in relation to the eastern coasts of Veragua, as Tortosa (at the mouth of the Ebro) is to Fuentarrabia (on the Bidassoa) in Biscay, or as Venice in relation to Pisa." Although Balboa first saw the South Sea from the heights of the Sierra de Quarequa on the 25th of September (Petr. Martyr, Epist. dxl. p. 296), yet it was not until several days later that Alonso Martin de Don Benito, who found a way from the mountains of Quarequa to the Gulf of San Miguel, embarked on the South Sea in a canoe. (Joaquin Acosta, Compendio hist. del Descubrimiento de la Nueva Granada, p. 49.)

As the taking possession of a considerable part of the west coast of the New Continent by the United States of North America, and the report of the abundance of gold in New California (now called Upper California) have rendered more urgent than ever the formation of a communication between the Atlantic States and the regions of the West through the Isthmus of Panama, I feel it my duty to call attention once again to the circumstance that the shortest way to the shores of the Pacific, which was shown by the natives to Alonso Martin de Don Benito, is in the eastern part of the Isthmus, and led to the Golfo de San Miguel. We know that Columbus (Vida del Almirante por Don Fernando Colon, cap. 90) sought for an "estrecho de Tierra firme"; and in the official documents which we possess of the years 1505 and 1507, and especially 1514, mention is made of the desired "opening" (abertura), and of the pass (passo), which should lead directly to the "Indian Land of Spices." Having for more than forty years been occupied with the subject of the means of communication between the two seas, I have constantly, both in my printed works and in the different memoirs which with honourable confidence the Free States of Spanish America have requested me to furnish, urged that the Isthmus should be examined hypsometrically throughout its entire length, and more especially where, in Darien and the inhospitable former Provincia de Biruquete, it joins the continent of South America; and where, between the Atrato and the Bay of Cupica (on the shore of the Pacific), the mountain chain of the Isthmus almost entirely disappears. (See in my Atlas géographique et physique de la Nouvelle Espagne, Pl. iv.; in the Atlas de la Relation historique, Pl. xxii. and xxiii.; Voyage aux Régions équinoxiales du Nouveau Continent, T. iii. p. 117-154; and Essai politique sur le Royaume de la Nouvelle Espagne, T. i. 2de édit. 1825, p. 202-248.)

General Bolivar at my request caused an exact levelling of the Isthmus between Panama and the mouth of the Rio

Chagres to be made in 1828 and 1829 by Lloyd and Falmare. (Philosophical Transactions of the Royal Society of London for the year 1830, p. 59-68.) Other measurements have since been executed by accomplished and experienced French engineers, and projects have been formed for canals and railways with locks and tunnels, but always in the direction of a meridian between Portobello and Panama, — or more to the west, towards Chagres and Cruces. Thus the *most important* points of the *eastern* and *south-eastern* part of the Isthmus have remained unexamined on both shores! So long as this part is not examined geographically by means of exact but easily obtained determinations of latitude and of longitude by chronometers, as well as hypsometrically in the conformation of the surface by barometric measurements of elevation,—so long I consider that the statement I have repeatedly made, and which I now repeat in 1849, will still be true; viz. "that it is as yet unproved and *quite premature* to pronounce that the Isthmus does not admit of the formation of an Oceanic Canal (*i. e.* a canal with fewer locks than the Caledonian Canal) permitting at all seasons the passage of the same sea-going ships between New York and Liverpool on the one hand, and Chili and California on the other."

On the Atlantic side (according to examinations which the Direccion of the Deposito hidrografico of Madrid have entered on their maps since 1809) the Ensenada de Mandinga penetrates so deeply towards the south that it appears to be only four or five German geographical miles, fifteen to an equatorial degree, (*i. e.* 16 or 20 English geographical miles), from the coast of the Pacific on the *east* of Panama. On the Pacific side the isthmus is almost equally indented by the deep Golfo de San Miguel, into which the Rio Tuyra falls, with its tributary river the Chuchunque (Chuchunaque). This last-named stream in the upper part of its course approaches within 16 English geographical miles of the Atlantic side of the isthmus to the west of Cape Tiburon. For more than twenty years I have had inquiries made from me on the subject of the problem of the Isthmus of Panama, by associations desirous of employing considerable pecuniary means: but the simple advice which I have given has never been followed. Every scientifically educated engineer knows that between the tropics, (even without corresponding observations), good barometric measurements (the horary variations being taken into account) afford results which are well assured to less than from 70 to 90 French or 75 to 96 English feet. It would besides be easy to establish for a few months on the two shores two fixed corresponding barometric stations, and to compare repeatedly the portable instruments employed in preliminary levelling, with each other and with those at the fixed stations. Let that part be particularly examined where, near the continent of South America, the separating mountain ridge sinks into hills. Seeing the importance of the subject to the great commerce of the world, the research ought not, as hitherto, to be restricted to a limited field. A great and comprehensive work, which shall include the whole eastern part of the Isthmus,—and which will be equally useful for every possible kind of operation or construction,—for canal, or for railway,—can alone decide the much discussed problem either affirmatively or negatively. That will be done at last, which should, and, had my advice been taken, would have been done in the first instance.

(19) p. 300—"*That which is awakened in us by childish impressions or by the circumstances of life.*"

On the incitements to the study of nature, compare Kosmos, Bd. ii. S. 5, (English edit. vol. ii. p. 5).

(20) p. 302.—"*Of importance for the exact determination of the longitude of Lima.*"

At the period of my Expedition, the Longitude of Lima was given in the maps published in the Deposito hidrografico de Madrid, from the observations of Malaspina, which made it 5h. 16m. 53s. from Paris. The transit of Mercury over the Sun's disk on the 9th of November, 1802, which I observed at Callao, the Port of Lima, (in the northern Torreon del Fuerte de San Felipe) gave for Callao by the mean of the contact of both limbs 5h. 18m. 16s. 5, and by the exterior contact only 5h. 18m. 18s. (79° 34 30″). This result (obtained from the Transit of Mercury) is confirmed by those of Lartigue, Duperrey, and Captain FitzRoy in the Expedition of the Adventure and Beagle. Lartigue found Callao 5h. 17m. 58s., Duperrey 5h. 18m. 16s., and FitzRoy 5h. 18m. 15s. (all West of Paris). As I determined the difference of longitude between Callao and the Convent de San Juan de Dios at Lima by carrying chronometers between them four times, the observation of the transit of Mercury gives the longitude of Lima 5h. 17m. 51s. (79° 27′ 45″ W. from Paris, or 77° 06′ 03″ W. from Greenwich). Compare my Recueil d'observations astron. Vol. ii. p. 397, 419 and 428, with my Relat. hist. T. iii. p. 592.

Potsdam, June 1849.

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OF THE

CONTENTS OF THE SECOND VOLUME.

GENERAL SUMMARY

OF THE

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